CENTRIC 2022

The Fifteenth International Conference on Advances in Human oriented and Personalized Mechanisms, Technologies, and Services

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CENTRIC 2022

Forward

The Fifteenth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services (CENTRIC 2022), held between October 16th and October 20th, 2022, continued a series of events on human-oriented and personalized mechanisms, technologies, and services, commonly known as I-centric. The conference provided a forum where researchers were able to present recent research results and new research problems and directions related to them. The conference sought contributions presenting novel result and future research in all aspects of user-centric mechanisms, technologies, and services.

The evolution of services and the diversity of the user profiles composed of various contents and context-based access led to the development of specific mechanisms, services, and applications with a definitive, personalized, and user-centric flavor. Mechanisms are in place for service discovery using user profiles, for adapting the traffic following the quality of experience, or allowing personalized navigation and visualization. More is needed for network control and feedback consideration as well as for personalized storage and information retrieval within a given context.

There is a cohort of technologies that favored the so called “user-centric” services and applications. While some of them reached some maturity, others are to prove their economics (WiMax, IPTV, RFID, etc.). Human-oriented and personalized technologies and services rely on a key set of features, some to be deployed, others getting more mature (personal profiles, preferences, identity, proximity, personal devices, etc.). Advanced applications covering human related activities benefit from personalized and human-oriented networks and services, especially preventive and personalized medicine, body networks and devices, or anticipative systems.

We take here the opportunity to warmly thank all the members of the CENTRIC 2022 technical program committee, as well as all the reviewers. The creation of such a high-quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and effort to contribute to CENTRIC 2022. We truly believe that, thanks to all these efforts, the final conference program consisted of top-quality contributions. We also thank the members of the CENTRIC 2022 organizing committee for their help in handling the logistics of this event.

We hope that CENTRIC 2022 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of human-oriented and personalized mechanisms, technologies and services.

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Ideating XAI: An Exploration of User's Mental Models of an AI-Driven Recruitment System Using a Design Thinking Approach

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***Abstract*— Artificial Intelligence (AI) is playing an important role in society including how vital, often life changing decisions are made. For this reason, interest in Explainable Artificial Intelligence (XAI) has grown in recent years as a means of revealing the processes and operations contained within what is often described as a black box, an often-opaque system whose decisions are difficult to understand by the end user. This paper presents the results of a design thinking workshop with 20 participants (computer science and graphic design students) where we sought to investigate users' mental models when interacting with AI systems. Using two personas, participants were asked to empathise with two end users of an AI driven recruitment system, identify pain points in a user's experience and ideate on possible solutions to these pain points. These tasks were used to explore the user's understanding of AI systems, the intelligibility of AI systems and how the inner workings of these systems might be explained to end users. We discovered that visual feedback, analytics, and comparisons, feature highlighting in conjunction with factual, counterfactual and principal reasoning explanations could be used to improve user's mental models of AI systems.**

Keywords - Artificial Intelligence; Explainable Artificial Intelligence; Design Thinking; User-Centred AI.

I. INTRODUCTION

AI is reforming the way that many processes and services are delivered in society. From deciding who is granted access to credit, who gains a place in third level education to which CV is chosen to progress to interview for employment [1]. Complex algorithms processing big data sets, which would otherwise be beyond the scope of human processing, are often making life-changing decisions with little human intervention and with even less explanation. This has given rise to an emerging field of XAI in which the results of AI systems and algorithms can be understood by humans. Of the XAI solutions which currently exist, many are designed by software developers for other software developers to explain how computer code and algorithms work [2]. Such approaches often rely on developers' own *"intuition of what constitutes a 'good' explanation"* [3]. Some useful solutions have been developed around text classification including the TextPlanation demonstrator which uses graphical means to display the results for different Machine Learning (ML) libraries including LIME, SHAP, LRP, SKATER and ELI5 [4] and the XPlainIT tool which visually explains the decision-making process of deep learning models [5]. Few XAI solutions are aimed at the end users of AI systems. This can be problematic when we consider the diversity of users who engage with AI systems, many of whom may have no technical knowledge of such systems. Other modalities have been explored such as the potential of virtual agents [6] and saliency based explainability models [7], which show potential and highlight areas of further research. To better understand end users' mental models of AI systems, cross collaboration and a more user-centred approach have been suggested [8]-[10], as well as drawing from Human Computer Interaction (HCI) philosophy and psychology [9]. Ultimately, understanding people informs explaining AI [9].

This paper seeks to describe our investigation into users' mental models for AI and ideate XAI solutions using cross collaborative, interdisciplinary participants using a design thinking methodology. Design thinking workshops were conducted using an AI design problem statement within a relevant discipline - recruitment, that could be well understood by lay users. Design Thinking activities were carried out with participants from both graphic design and computer science backgrounds which were used to explore how users understood the proposed AI system and to uncover blind spots in their understanding and associated challenges. We hoped to explore what users' "internal representations" [11] of AI systems that might be based on their real-world experiences and build on this to develop ideas as to how these AI systems might be more usefully explained. The rest of this paper is structured as follows: In Section II, we describe related work on Design Thinking and mental models, in Section III, we describe our approach to ideating XAI using design thinking, in Section IV, we describe the results of the design thinking session including users' approaches to solve AI system pain points. We conclude by highlighting areas for future work.

II. BACKGROUND

2.1 Design Thinking

Over the course of the last century, the professional practice of design has evolved to include a much wider

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range of disciplines including addressing social problems, business management and within the world of information technology design. It has been suggested that those who are non-designers could benefit from thinking like designers [12]. One approach which has emerged within the field of user experience design to help bridge this gap is design thinking. Design thinking can be described as a problem-solving approach which prioritises users' needs using a non-linear or iterative process with well-defined stages: empathise, define, ideate, prototype, test [25]. Our study focuses primarily on two stages: empathising and ideation as two of the most useful stages for determining users' mental models. Further research will concentrate on other phases. Fundamental to design thinking is the concept of empathy, connecting with those who use our products or services on a deeper level by considering what a user might do, say, think and how they might feel whilst engaging with a product or service. Persona development and empathy mapping are two design thinking activities which can be used to facilitate this [15] in conjunction with pain point identification, big ideas ideation and prioritisation [16].

2.2 Mental Models

Mental models describe what a user believes they know about a system such as an information system. The ultimate goal of any software designer or developer is to build a system where users can build accurate and as a result useful mental models [17]. In essence mental models refer to a user's expectation of how a system should work [18]. In the case of predictable systems within digital technology the theory of mental models has proven useful [19]. However, within AI where systems are complex, less predictable and change over time this approach can be difficult to apply. It has been argued that explainability and comprehensibility, with regard to user interaction, should employ the use of specific use cases, putting the user at the centre of XAI [20]. As well as the ethical need for explanations in AI, legislation such as the EUs General Data Protection Regulation (GDPR), the USAs Algorithmic Accountability Act 2022 and the UKs Digital Regulation Plan demonstrate that lawmakers realise the importance of accountability and transparency of algorithms [21]-[23].

III. PARTICIPANTS

We conducted a design thinking workshop with students from an Irish College of Further Education. University ethical approval for the workshop was sought in advance and consent forms acquired. Inclusion criteria for the study included expertise in Computer Science and/or Design. Participants were invited to partake via email. The final participants included 20 students. Prior to the workshop, a Microsoft Forms survey was distributed to establish demographics and their knowledge, if any, of AI, XAI and Design Thinking. 20 participants in total were divided into 4 groups of 5 participants.

Group 1: 2 designers & 3 computer scientists, 5 males: Andrew Wilson Persona.
Group 2: 2 designers & 3 computer scientists, 1 female & 4 males: Andrew Wilson Persona.
Group 3: 3 designers & 2 computer scientists, 3 females & 2 males: Maria Atkins Persona.
Group 4: 2 designers & 3 computer scientists, 5 males: Maria Atkins Persona.

The participants comprised 11 computer science students and 9 design students supporting our interdisciplinary, collaborative approach [9]-[12]. 11 participants identified as undergraduate students while 9 identified as mature student / professional returned to education. 11 participants were aged 18-24, 5 were aged 25-34 and 3 were aged 35-54. 4 participants were female and 16 were male. See Figure 1. 4 groups of 5 participants were formed for 1 design thinking workshop.

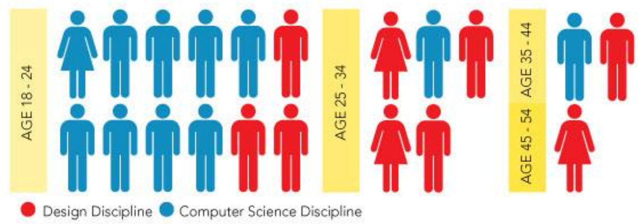

Figure 1. Participant Profile.

IV. METHODS

4.1 Persona Design

It has been estimated that at least three quarters of all CVs submitted for jobs in the US are processed by AI [14]. Efficiency and cost savings are the main motives for employing AI in candidate selection; however, a recent report from Harvard Business School showed that 88% of employers agree that suitable candidates are vetted out of the system because they do not match exact criteria [29].

After selecting the problem domain, 2 design problem statements were presented which introduced participants to 2 personas: How can we help Maria (a recruiter) understand the CV filtering systems she is using and ensure possible suitable candidates aren't slipping through the net? And, how can we help Andrew (a job seeker) understand the process involved in how his CV is being screened for interview selection and increase his confidence in the system? Personas are an important tool which are used to align designers and developers to user experience and in at least some settings can be used to great effect [13]. To better understand end user problems related to AI systems for employment and recruitment, we designed two personas reflecting differing user experiences. Andrew Wilson was designed as a job seeker engaging with a recruitment application whereas Maria Atkins was designed as a

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recruiter using the application for processing candidates for interview. See Figure 2.

Figure 2. Personas referenced during workshops [30][31].

Andrew is a recent highly qualified computer science graduate but has some characteristics which may be considered atypical, for example, his relatively older age and his background when compared to other university graduates. These characteristics were by design as such features may exacerbate historical biases in datasets used by AI systems [1]-[14]. Maria was designed to reflect the experiences of many working in the recruitment sector where algorithms are now commonly used to filter candidates without providing explanations of why candidates are selected or not [1].

4.2 Design Thinking

The design thinking process begins with empathising, followed by pain point definition and finally ideation and evaluation.

4.2.1 Empathy mapping & As is scenario

Participants engaged in two empathising activities

1. Empathy mapping: considering persona's thinking, feeling, saying and doing
2. As is scenario: Identification of steps and persona's thinking, feeling and doing

These activities are to facilitate pain point identification.

4.2.2 Pain Point Identification

Pain point identification was carried out using 5 sticky dots per participant. This was followed by a playback or presentation of each group's main findings.

4.2.3 Big ideas & Prioritisation

Ideation in the form of big ideas and prioritisation follows pain point identification. This involves:

1. Grouping of similar pain points
2. Identification of 4 pain points
3. Design of 3 solutions and 1 absurd solution for each pain point
4. Voting using 5 sticky dots on most feasible and important solutions
5. Prioritisation using XY grid, X Axis = feasibility for us, Y Axis = importance to the user. This categorises solutions into no brainers (High Importance to the user & High Feasibility for us), big bets (High Importance to the user & Low Feasibility for us), unwise (Low Importance for the user & Low Feasibility for us), utilities (Low Importance for the user & High Feasibility for us).

4.3 Data Collection and Analysis

At each stage of the design thinking workshop, data was collected using digital photographs of each activity sheet with post its and voting sticky dots included. Playbacks of critical moments were recorded for transcription post workshop. The workshop concluded with a short group interview with questions designed to ascertain participants' engagement with the processes and to further explore their mental models regarding XAI. Audio was also recorded of post workshop interviews. Content analysis followed identifying common categories linked to pain points.

V. RESULTS

Results are divided into two parts. Firstly, we present an overview of the findings from the design thinking activities which includes participants' responses to empathy mapping and as is scenarios to identify pain points in users' engagement with AI. We follow with a content analysis of participants "big ideas" or ideation linked to pain points identified earlier. We interpret the findings of this analysis with an emphasis on presenting common categories identified during workshop exercises.

To categorise our results more effectively, we combined the findings for each persona. Findings for groups 1 and 2, those that empathised with Andrew Wilson, were grouped together as were findings for groups 3 and 4, who empathised with Maria Atkins.

5.1 Empathy Map & As is Scenario Groups 1 & 2

Groups 1 & 2 associated the process of making job applications and continually being rejected as being a negative experience, which is to be expected. Emotions such as "Depressed", "Upset", "Angry" and "Unmotivated" featured predominantly. Empathy mapping was followed by an As Is Scenario where groups broke Andrew's process into steps and delved further into the thoughts, feelings and actions associated with each. Group 1 broke a job application process for Andrew into the following steps: search, apply, receive replies, analyse, revise CV and call or reapply. Group 2 broke a job application process for Andrew into the following steps: Revise CV, Internship application, email the companies about what he should do and look outside this country.

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5.2 Pain Point Identification

Voting followed using sticky dots where each participant used 5 sticky dots to vote on the areas of most pain for our persona. Both groups identified similar pain points which included the process of applying and reapplying, continually revising CV, receiving a negative response and lack of feedback.

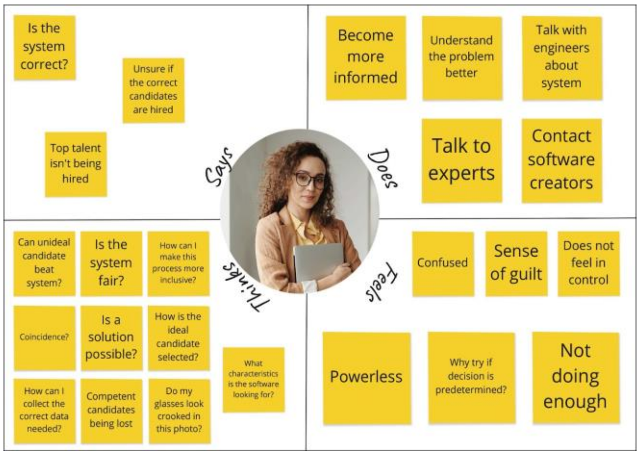

Figure 3. Graphical Representation of Empathy Map Group 4 [30].

5.3 Empathy Map & As is Scenario Groups 3 & 4

Groups 3 & 4 associated Maria's engagement with the recruitment system as being opaque and confusing. They described Maria as feeling "Confused", ``Powerless" and having a sense of "Guilt". See Figure 3.

Figure 4. Graphical Representation of As is Scenario with Pain Point Voting Group 4.

To further empathise with Maria an As Is Scenario exercise followed. Group 3 broke Maria's steps into the following stages: logs into system, researches, documents her concerns, contacts management, voices concerns. Group 4 took a slightly different approach and looked at Maria's initial steps in dealing with both successful and unsuccessful candidates. Group 4 steps included: review successful applicants, manually send out successful emails, review unsuccessful applicants, message unsuccessful applicants, call the IT person, inform senior management of concerns. Although slightly different, both groups ended with Maria documenting her concerns and voicing them to those in authority in the hope that a solution can be found. See Figure 4.

5.4 Pain Point Identification

Both groups continued to the next activity, pain point voting using 5 sticky dots each. Figure 4 represents the findings of Group 4 with pain point voting represented and 4 pain point areas circled. Similar pain points emerged from both groups which included the process of researching or reviewing the system, reviewing, and messaging unsuccessful applicants, identifying who can help and conveying her concerns. See Figure 5.

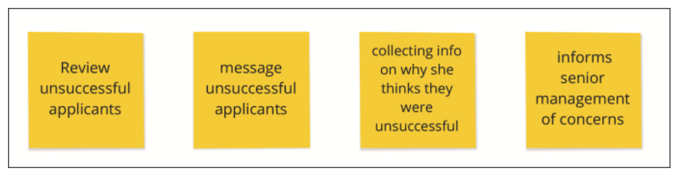

Figure 5. Graphical Representation of Pain Point Identification Group 4.

5.5 Big Ideas & Prioritisation Groups 1 &2

In response to these pain points groups 1 & 2 began the process of big ideas ideation and prioritisation. Each participant designed 3 solutions for each pain point and one absurd solution. After a second round of voting using 5 sticky dots each the most promising big ideas were identified. These were then placed on a prioritisation grid the main findings of which can be seen in Table I.

5.6 Big Ideas & Prioritisation Groups 3 & 4

Groups 3 & 4 carried out the same process of ideating on big ideas to solve the pain points for our persona Maria which were identified earlier. This followed with voting on the potential of these ideas and placement on a prioritisation grid. Table II documents the main findings of this process.

Participants' final task, playback of big ideas and prioritisation gave an opportunity for each group to explain in more detail their big ideas and reasoning for their choice of placement on the prioritisation grid.

We consolidated findings from our design thinking workshop and conducted a categorisation exercise to cluster or group common big ideas into similar topic areas. Our findings identified three categories associated with each persona and interestingly two overlapping categories for each. We coded each big idea as follows:

- Visual feedback & analytics: 01
- Visual comparisons: 02
- Highlight problems & offer chances to rectify: 03
- Criteria manipulation / tracking: 04

Figure 6. Categories for both personas to understand AI system [30][31].

Visual feedback and analysis and visual comparisons were considered necessary for both Andrew and Maria to understand the AI-driven recruitment system. Highlighting problems and offering chances to rectify were considered necessary for Andrew and criteria manipulation and tracking was considered necessary for Maria. See Figure 6. Tables I & II document big idea categorisation.

TABLE I. BIG IDEAS, PRIORITY, CATEGORY GROUPS 1 & 2

Pain Point > Big Idea > Priority > Category			
Pain Point	***Big Idea***	***Priority***	***Category***
Negative replies & Rejection	Call for interview	No brainer	01
	Ask for feedback	No brainer	01
Revise CV	Compare past & present CV	No brainer	02
	Highlight problems on CV	Big bet	03
	Score in categories	Big bet	01
	Check CV similarity stand out	No brainer	03
Search & Apply	Create dashboard of applicants & show success	Big bet	01
	Template CVs	Utilities	02
	Guides	Utilities	02
Reapply / Apply again	Visual results	No brainer	01
	Rating (stars)	No brainer	01
	AI that creates data that helps person change parts in CV	Big bet	03
	Make it fun / a game	Big bet	03
Ask for feedback	Analytics / visual feedback	No brainer	01
	Virtual Agent / Concierge	Utilities	01
	Clippy	Unwise	01

Pain Point > Big Idea > Priority > Category			
Pain Point	***Big Idea***	***Priority***	***Category***
	Visual CV feedback	No brainer	01

TABLE II. BIG IDEAS, PRIORITY, CATEGORY GROUPS 3 & 4

Pain Point > Big Idea > Priority > Category			
Pain Point	***Big Idea***	***Priority***	***Category***
Researching / Reviewing system	Provide visual statistics to explain AI system's decision	No brainer	01
	Category / criteria selection or manipulation	No brainer	04
	Hire someone else to fix system	Big bet	
Reviewing & messaging unsuccessful	Multiple job to candidate criteria matching	No brainer	02, 04
	Candidate pooling	No brainer	02, 04
	Double validation: checking successful and unsuccessful candidates' data for errors or untruths	No brainer	04
	Bias tracking	Big bet	04
	Theme identification related to unsuccessful applicants	No brainer	04
	Inform applicant how to improve	No brainer	02
Identify who can help	Clippy	No brainer	01
	Virtual agent	Utilities	01
Inform senior management of concerns	Visual Record	No brainer	01
	Audit report to share with management	No brainer	01
	Compare / track old system with new one	No brainer	02

One area of interest which we used to interpret our findings was the participants' use of drawing and visual ideation to explain their concepts in how both personas might better understand AI.

Figure 7. Participants visualisation of visual feedback & analytics.

Since drawing is encouraged as an integral part of design thinking activities, participants' visual interpretations

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of how AI might be explained resulted in thought-provoking ideas which informed our allocation of categories [24]. For example, participants described visual analytics showing a job applicant's score in categories related to keyword matching. *"Here are analytics with tables and charts so you can see if you want to hire someone…some sort of visuals or charts to say this is your rating for your employment history or this is your rating for your software skills…stars even"*. See Figure 7. Highlighting perceived flaws or poor keyword matching in an applicant's data was also considered. *"We looked at comparing past and present CVs and highlighting problems on a CV so if the person's CV is lacking or they have something written on it that they shouldn't, highlight those"* See Figure 8.

Figure 8. Participants visualisation of highlighting problems & offering chances to rectify.

VI. DISCUSSION

Our findings support research into the use of feature highlighting using factual explanations, for example, why the system produced certain results, versus counterfactual explanations, why the system produced one result over another, to better explain AI to users [26]. When a user's expectation is matched to the output of the system, in this case a job applicant believes they are suitable for a role or a recruiter expects certain applicants to receive an interview, factual explanations should be used. In the case of our personas, Andrew would expect CV rating, analytics or visual feedback if his application was successful or unsuccessful: "You scored 1 star in team working skills" or "You scored 20% in years' experience". However, a more useful explanation would be found in a counterfactual explanation when Andrew's expectation of the system is not met. Explanations highlighting why one decision was made over another would better explain the system's decisions [27]. "You were unsuccessful as your score of 1 star in team working skills should be at least 5 to progress to the next stage". This can be further explained using principal reason explanations where the factors which dominated the system's decision are explained but allow the user to act and receive a different result [27] which in Andrew's case would include being given an explanation highlighting features on his application which determined a negative result and allowing updates and reapplication. As such "You were unsuccessful for this job application because you only have one previous role which included team working skills. You should have at least 5 team working roles. Is this information correct?". For our recruiter, Maria, counterfactual explanations could be used to explain candidate selection not only for those that are successful but also for those that are unsuccessful and principal reason explanations to allow her to manipulate criteria and allow for a different result [30]. For example, "No female candidates were offered interviews due to CV gaps of over 6 months. Would you like to disregard CV gaps?" Although dealing with the domain of recruitment our findings could be useful within many other domains which utilise AI for data processing. Interestingly many of these mental models align with Nielsen's usability heuristics such as visibility of system status, match between system and real world and help users recognise, diagnose, and recover from errors [28]. Challenges encountered during workshops included logistical difficulties related to audio recording of large groups and photographing participants work. Audio tests carried out preworkshop concluded that one recording device located at each group, in this instance 4 audio recording devices, were necessary. Also, we found that recording of playbacks at significant stages, after empathising and pain point identification and after big ideas and prioritisation, was crucial in understanding participants contributions. Essential to successful data collection was the photographing of participants worksheets after each stage. We also engaged workshop facilitators to ensure that groups were focused on the problem statement, personas' engagement with the AI system, rather than solving the issue of recruitment in general.

VII. CONCLUSION

We present an exploration of user's mental models of an AI driven recruitment system where we put the user at the centre of our study. By engaging a design thinking approach with interdisciplinary participants, we discovered novel approaches for participants to communicate their understanding of AI systems and for researchers to understand their internal representations. Future work in this area should also centre around usability heuristics, more commonly referenced in HCI and user interface design, which should also be applied to more complex systems such as AI.

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Systems and Productivity Metrics – a Review

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***Abstract*— Nowadays, the industry produces a large amount of data in its daily activities. Invested time and resources in acquiring, storing, and managing this data can represent a huge added value to organizations decision makers. Besides data produced by information systems used to support operational tasks, additional data can also be acquired and stored automatically, without human interaction. In Industry 4.0, technologies are becoming more prevalent in production and logistics. Intelligent sensors can generate a large volume of industrial data, so it is crucial to collect, store, analyze, and distribute this data in organizations. Dashboards allow operators to make informed decisions and solve issues on the fly. Thus, to address the presented concepts, a systematic review was conducted, based on Preferred Reporting Items for Systematic Review and a Meta-Analyses guideline (PRISMA). These studies address some consistent positive evidence on the use of Internet of Things (IoT) technologies to support productivity metrics in industry, creating knowledge for the development of a digital solution.**

Keywords: Productivity metrics; Industry 4.0; Internet of Things; Systems; Key Performance Indicators.

I. INTRODUCTION

Making a good plan for a given task is the key to success in any business area. To make the best decisions, an analysis of the organization's data is necessary. Data collection is as essential as its analysis. In a computerized world, data collection is fundamental, regardless of the business areas in which this collection occurs. Fortunately, IoT solutions and computer solutions collect a huge amount of data every day and help us optimize and analyze a specific business area in the best way, thus supporting decision-making through data analysis. These IoT solutions are found in different business areas, from small to large technology companies. One sector that has been growing with the help of IoT is the primary sector, giving rise to IoT Smart agricultural solutions [1]. The present study follows the PRISMA [2] methodology. It provides a comprehensive review of the scientific literature on the use of IoT technologies to support productivity metrics in the industry. This review is important because it presents an identification of the approaches used in productivity metrics in the industry and identifies a set of opportunities that can be explored in future research. However, it also has some limitations. The literature search was performed only in three databases (IEEE Xplore, ACM Digital, and Scopus), which may have influenced the number of relevant studies obtained. The use of other databases could possibly have increased the number of studies analyzed and contributed to improving the general analysis, as well as the search strategy, which had restricted the number of non-relevant studies (studies published many years ago, very general studies, studies that do not focus on the research objectives, or studies not written in English). However, these restrictions did not have a significant effect on the discussion and conclusions.

This paper is organized as follows. Section II presents the details of the methodology and the results that were obtained through the research. Section III presents the conclusions and directions for future work.

II. METHODOLOGY

This section aims to analyze scientific articles that contain information related to tools and technologies associated with data collection and visualization and treatment of related data and respective metrics. This review includes the following topics: research questions; inclusion criteria; search strategy; results; extraction and data analysis; discussion.

Research Questions

According to the proposed objectives, the research questions are addressed in this topic are:

Question_1: What systems exist to measure productivity?
Question_2: What kind of metrics are used to collect information?
Question_3: What kind of frameworks/tolls allow the data collection?
Question_4: What data analysis and visualization tools are possible and used?

Inclusion criteria

The literature studies are selected according to the following criteria.

Criterion_1: Studies published between 2017 and 2021.
Criterion_2: Studies written in English.
Criterion_3: Studies where the full texts are available free of charge.
Criterion_4: Studies regarding IoT solutions.
Criterion_5: Studies concerning tools and technologies associated with productivity and the identification of metrics and data visualization/treatment.

Research Strategy

The IEEE Xplore, ACM Digital and Scopus databases were used in the research to identify the articles. The set of search terms was: "Industry 4.0", "IoT", "Framework", "Assessment", and "Key Performance Indicators (KPI)". The search was carried out between November and December 2021.

Results

As shown in Figure 1, after carrying out the search and applying criterion 1, 206 scientific articles were found, 24 from the IEEE Xplore database, 86 articles from the ACM Digital database and 96 articles from the Scopus database. Applying criterion 2 and removing duplicates resulted in the exclusion of 18 studies. Thus, 188 studies were analyzed based on title and abstract, and 152 were excluded, based on criteria 4 and 5. Complete text analysis of the 36 resulting studies was performed, applying criteria 3, 4 and 5. The remaining 13 studies were included in the review.

A. *Extraction and Data Analysis*

Data were extracted from all identified studies using a predefined format: Study; Year of publication; Metrics; Technologies, and Data Visualization. Table I presents the extracted data. The characteristics of the included studies are summarized below.

In [1], the authors explore ways of visualizing data collected from IoT systems. They address the importance of data and its visualization to support decision-making and indicate some of the most used tools in different industries, such as Tableau, *Thingsboard*, *Plotly*, IBM Watson IoT Platform, Power BI (Business Intelligence), Gephi, Grafana, Kibana Tool, JavaScript libraries, frameworks, and toolkits. They refer to these tools as the most used for viewing data quickly and dynamically. This article refers to different business areas, highlighting the importance of viewing these collected data.

The study carried out in [3] focuses on the importance of data collection and the monitoring and productivity of employees, developing an Industrial Internet of Things (*IIoT*) system. The project primarily addresses business areas where employee monitoring is required. Additionally, machines need to be used on the shop floor to operate, where the information collected through "wearable sensors" and processed and stored in the Cloud. KPI are produced for each employee through this collection of information. In this study, a factory where employees must cut meat was used as an example. In addition, to propose a solution to the problem, the employees use a wearable technology called “MetaWear”. The sensors send the information through Bluetooth Low Energy (BLE) to the Raspberry Pi, used as a gateway. All the collected data is sent to the Cloud. As an interface for employees, Andon systems were used. However, several KPIs were calculated, with the data collected and analyzed without referring to the tools used for their visual analysis.

In the study presented by [4], a new Andon system was proposed, referring to the importance of the employee on the factory floor being able to quickly, through the colors, understand what is happening and act accordingly, as quickly as possible. Thus, a new interface was proposed to maximize

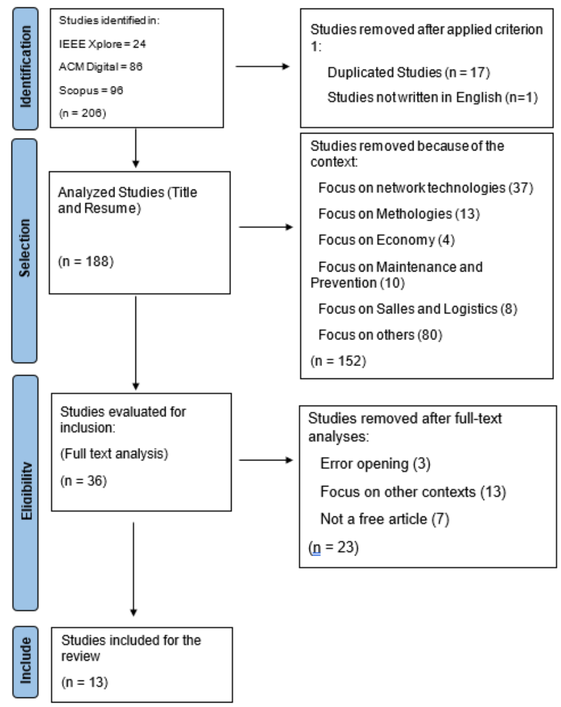

Figure 1. Flow diagram for new systematic reviews (adapted from [2])

TABLE 1. EXTRACTED DATA

Study	Metrics	Technologies	Data visualization
Data visualization on the internet of things: tools, methodologies, and challenges [1]	N/A	N/A	Tableau, Thingsboard, Plotly, IBM Watson IoT Platform, Power BI, Kibana Tool, JavaScript libraries, etc.
An Industrial IoT Solution for Evaluating Workers' Performance Via Activity Recognition [3]	Productive and non-productive work time	Wearable Technologies, Cams, RFID, NFC, Bluetooth Low Energy Sensor	Andon Systems
Designing usable interfaces for the industry 4.0 [4]	N/A	N/A	Andon Systems and Stacked Bar, Line and Ring Graphs
Microservice architecture in industrial software delivery on edge devices [5]	N/A	Microservices and Pipeline	N/A
Modelling and assessing the effects of digital technologies on KPIs in manufacturing systems [6]	Overall Equipment Effectiveness (OEE), Time, Quality, Product Quantity	RFID, VR (Virtual Reality)	N/A
Key performance indicators in the production of the future [7]	Data Management, Transparency and networking, Product Management	Profitability-Liquidity KPI system, DuPont System of Financial Control	N/A

Study	Metrics	Technologies	Data visualization
Developing key performance indicators tree for lean and smart production systems [7]	Product Control, Equipment Productivity	Bosch Production System, PLCs, CNC Work Centers	N/A
Motion Analysis System for the digitalization and assessment of manual manufacturing and assembly processes [9]	Movement distance and speed, Vertical movements, Workstation utilization, Productive and non-productive work time.	Motion Analysis System, MOCAP (Motion capture system)	Bar and circular bar chart
MAESTRI Efficiency Framework: The Concept Supporting the Total Efficiency Index. Application Case Study in the Metalworking Sector [10]	Manufacturing process	ecoPROSYS	Bar and pie charts
Line Balancing Assessment Enhanced by IoT and Simulation Tools [11]	OEE, Employee Performance, Productivity Collection	N/A	N/A
Auditing and Assessment of Data Traffic Flows in an IoT Architecture [11]	Traffic Flow	Application & Microservice Monitor and Analyser	DevDash
Modelling food supply chain traceability based on blockchain technology [13]	Product Control, Quality, Process Control	N/A	N/A
Cognitive internet of things for smart water pipeline monitoring system [14]	Control and monitoring of water pipes, water leakage, water pressure and flow rate	N/A	JavaScript e Ajax

usability. The rapid transmission of knowledge and events is vital so that accidents or more serious problems do not happen. In addition, it refers to the KPI of machines on the shop floor and not the employees. A prototype was made for the Andon systems, where the following principles were implemented and tested: information made available in a hierarchy; multi-window interaction; multitouch interaction and self-explanatory diagrams. To test usability, 18 participants tested the system, playing the role of a worker. Through this test, it was possible to visualize that with the new interface, the efficiency, and the interaction of the employees with the system improved.

The work in [5] portrays a microservices system and pipeline in Industry 4.0. Unlike what happens in monolithic systems, this approach allows the management and delivery of software to the different devices without stopping the entire production system to simply apply new features. This problem happens when the system "is dominated by the monolithic architecture", and this type of system requires "a production stop planning for the manual installation" of updates. The author defines as primary objectives of the study the focus on the requirements and architecture of the application system and the introduction of pipelines for the delivery of software that comes against the manual installations in traditional industries. In addition, an analysis application was developed in Supervisory Control and Data Acquisition (SCADA) systems, where the objective is the analysis and measurement of data, where the end-user defines what type of metrics can be taken from the system, which, according to the author, could be "productivity, Overall Equipment Effectiveness (OEE), etc.". Despite referring to these KPIs, the article focuses more on the application of pipeline systems in the industry, which, in a way, comes to revolutionize with cutting-edge technology that, monolithic systems are dominant in traditional industries present in the market.

The work in [6] mentions an approach for companies to select an appropriate digital technology, considering the objectives of each business idea. Thus, different KPIs are approached and categorized, the best forms of information collection are exemplified, and some examples of technologies to be used are also presented. This study made it possible to identify some types of indicators for which information can be collected. In addition to the OEE, information such as time, quality and quantity of product can also be collected. The KPIs presented are structured in 4 groups: Process, Worker; Financial; and Customer. Two types of technology were also proposed, depending on the objectives: Radio Frequency Identification (RFID) and Augmented Reality (AR).

In [7], the main objective is to present new KPIs for the industry in the future and mentions some challenges that it must face in relation to the availability and collection of information. Some current KPIs in the financial sector are discussed, such as the "DuPont System of Financial Control" programs, "ZVEI KPI System"; "Profitability-Liquidity KPI system". In addition, reference is made to ISO 22400 as a framework for structuring production KPIs. However, despite these examples, it is mentioned that they are not useful, as they are not flexible enough for the collection of information and as such, they propose a new framework considering Porter's Value Chain. In addition to existing KPIs, such as Logistics, Production process, and Quality, the work proposes three new groups: Data management, Transparency and Networking, and Product Management. Once collected, the data can be visualized and analyzed using the "Harvey-Balls" graph. These pie-shaped graphs are used to visualize qualitative data. Although they refer to this type of graph, it only represents a form of information visualization and not a data visualization framework.

The authors in [8] propose a KPI tree structure to describe a Performance Measurement System (PMS), with the data collected, the system recognizes the failures in the actual productivity. This study used as an example a Bosch factory where "Lean Manufacturing" or "Lean Production" is applied. This system called Bosch Production System (BPS) is based on the maximum reduction of the waste in the production flow, with the ideal state of 100% deliveries, 100% added value and 0 defects. The system also supports the decision-making process. They identify three areas of process cycles: "Source", "Make", and "Deliver", which describe the objectives of projects related to Industry 4.0. In this way, the hierarchical structure of the proposed KPIs offers real-time measurements and performance calculations. Using the identified process cycle areas helps collect all the information to focus on continuous improvement and thus achieve the defined objectives.

In [9], the authors present the "Motion Analysis System" system that digitizes employees' operations in different production environments. A Motion Capture (MOCAP) system was introduced and adopted, initially used in the gaming industry for the manufacturing environment. This system can collect and analyze measurements related to productivity and performance. Cameras were used to capture the employee's movements, which are connected to a computer via USB, whose main function is to send data via Wi-Fi. The main KPIs which can be analyzed through this system are: Physical distance travelled and speed of movement; Vertical movements (operator needs to lift or lower something); Use of the workstation by the employee; Working time (productive and non-productive).

In [10], the main objective is to collect information and reduce waste, focusing on sustainability. This project is based on "Multi-layer Stream Mapping", responsible for accessing process efficiency and ecoPROSYS, a quantitative management tool that assesses the environmental impacts of a production cycle. The collected data is transformed into KPI where Value Added (VA), Efficiency, Ecoefficiency, and Total Efficiency Index (TEI) are calculated.

In [11], the main objective is to propose a framework that, from Industrial Internet of Things (IIoT), collect information regarding the performance of employees and machines. Thus, the proposed system has the collection and sending of production data in real-time as its main objective. Employee data is calculated and collected. There is an evaluation of the employees in terms of workload, the number of parts produced and OEE for the equipment. It presents formulas for calculating the indicators mentioned above. However, it does not refer to the technology used, focusing more on the result and analysis of the calculations of the optimization of production processes, seeking the efficiency of the process and employees.

The study in [11] has as main objective a solution that processes, stores, monitors, and indexes data from different IoT and Smart City devices to control and monitor the flow of traffic of motor vehicles. The solution uses *DevDash* (Developer Dashboard) to index data from devices and Application & Microservice Monitor and Analyze (AMMA) tools for real-time data control and monitoring the traffic flow. Data is collected in real-time and stored in a non-relational database. This data is processed by a tool called "Apache NiFi", whose main objective is to optimize big data flow. The *DavDash* and AMMA tools also contain and work data, placing it in a visual way ("Both AMMA and *DevDash* include a set of classical dashboard widgets to visualize data such as histograms, time-pickers, filters, facet selection on the different kind of data managed, heatmaps, pie charts, tables, and newly created panels (...)").

In [13], the main objective is to create an "autonomous, functional and back-end system where data is not centralized" that benefits all food-related industry players. The tracking includes the process, the product, and the quality control. For tracing a Table of Content (ToC) is suggested, containing all product information stored locally in an Interplanetary File System (IPFS). Some KPIs are calculated, however, for the system itself "efficiency, responsiveness, required trust assumptions, context requirements, required consensus mechanisms and food quality of the proposed blockchain-enabled mode". Despite referring to a good form of data transmission and tracking, they do not indicate what type of IoT technology was used, nor what type of system was used to visualize the KPI themselves indicated above.

In [14], the authors have as their central objective the proposal of a system of "control and monitoring of water pipes". The IoT solution presented uses the Apache Spark framework for big data processing. A "Wireless Actuator Sensor Network" sensor was used to detect and locate water leakage. Data such as water pressure and flow speed are collected and sent over Wi-Fi. This data is processed and placed in the Cloud. It was then worked and presented on a website using JavaScript and Ajax.

B. Discussion

The discussion is based on the results presented in Table 1. The articles analyzed were published between 2017 and 2021. Of the 13 articles for more detailed analysis, 46% refer to the year 2018, 30 % to 2019, 24% reference 2020, and 0% for 2017 and 2021. Figure 2 describes the result obtained in several articles per year, where it is verified that in three of the years analyzed, no results were obtained. Although specific studies refer to quality control or process and product management, it could be tried to infer what kind of metrics could be collected; however, their description was not explained.

In Figure 3, some of the metrics referenced in the analyzed studies can be observed. Although 19% of the articles did not refer in detail to what metrics were collected, all referenced the collection of information and the importance of obtaining, or not, a vision of achieving the defined objectives, thus allowing the identification of improvement points, either at the level of quality control or at the human or machine level. Two critical metrics, illustrated in Figure 3 are the employee's productive and non-productive working time. Productive work can be counted (concept mentioned in 19% of studies), and the non-productive work deduced (this concept mentioned in 14% of studies).

As for technologies, as illustrated in Figure 4, there is no reference in 29% of the studies. The other studies analyzed refer to technologies dedicated to the problem in question, something expected for projects where IIoT is present. Despite this, RFID and Microservices and Pipeline technologies outnumbered the remaining ≈6% of the remaining technologies. The RFID technology was referenced in cases where the authors intended to have greater process control, quality control, product tracking and real-time and automatic data collection. Concerning achitec-

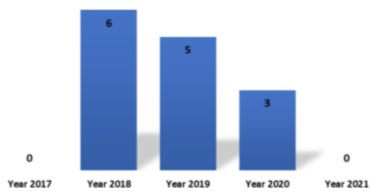

Figure 2. Number of studies per year

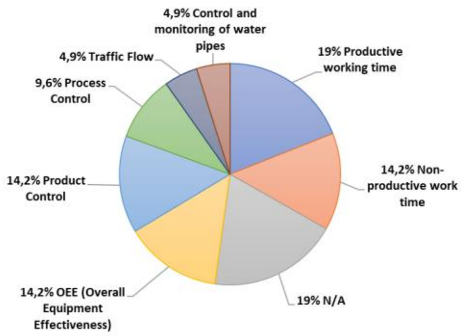

Figure 3. Metrics Used

ture in Pipeline, it was referenced as an innovative architecture for industrial systems, thus contradicting the old monolithic system. Near Field Contact (NFC) technology was also referenced as a suitable technology for tracking, however, it was only reported in 5.9% of studies. The collection of all information is an important process, but no less relevant is the analysis and study of the data collected. Given the vast alternative solutions for data visualization, as in technologies, no emphasis was observed, as illustrated in Figure 5. The highest visualization reference in the studies concerns the graphic representation, yet 41% of the studies did not refer to the type of tools used to visualize the data. However, analyzing the two tools that obtained a higher percentage of reference stand out with 9% the Andon systems, something expected to exist on any fabric floor. For systems that use JavaScript, a percentage of 9% was also obtained compared to the systems mentioned in all articles. Andon systems make sense for the fabric floor and sometimes on the same interface of the machine where the operator is working. Systems developed in JavaScript make more sense in being used when a website is needed, usually to represent data collected in production. After analyzing scientific articles, it became clear that IoT systems are highly sought after in different sectors and business areas, being very understandable for their usability. This study was essential to identify which technologies should be implemented and which KPIs to be calculated. After analyzing the different articles and obtaining the answers to the questions at the beginning of this document, we can conclude that there are different technological solutions for each problem. General systems and/or systems may be developed to address a particular problem. Thus, of the thirteen articles analyzed, the main conclusions drawn were:

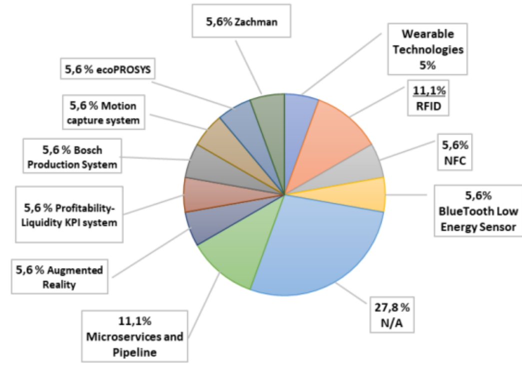

Figure 4. Percentage of technologies

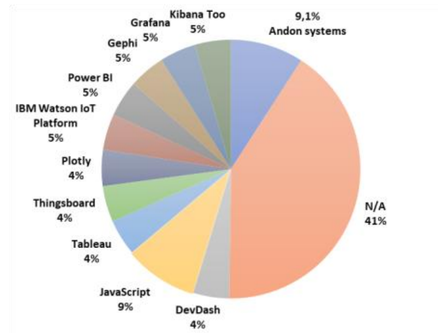

Figure 5. Data Visualization Tools

Question 1: What systems exist to measure productivity?

Several systems have been put forward to answer this question. Some studies had the presence of a new tool for measuring productivity as their primary objective. Others chose existing systems as the basis of their study and presented proposals for improvement. Thus, information collection systems can be divided into two groups: the first group belongs to the general systems, which serve as a solution for various business ideas. The second group refers to the dedicated systems developed to respond to a given problem. In the general systems group, some names appeared throughout the study, such as: Bosh Production System [7], and MAESTRI Total Efficient Framework [10]. In the second group, the systems are based on the development of IoT [3][11]-[14]. These systems are flexible in the type of technology they use, but all with a single common goal, data collection. In addition to these groups, articles brought another type of innovation to the industry, such as pipeline systems, focusing on the importance of not having a monolithic system and the management issues that these monolithic systems bring to the industry or any system that implements it [5]. A group of systems was also mentioned throughout the study, the Andon systems. Despite being significantly related to the fabric floor's machinery and color system, these systems can also contribute to the collection of productivity information. These systems allow for measurements and present visual solutions that help improve the interaction with the machines by the employee. [4] proposed a new interface in Andon systems that significantly improves the usability of systems.

Question 2: What metrics are used in the collection of information?

Throughout the research, it was clear that the metrics to be used were dependent on the type of analysis desired. Metrics can refer to equipment but also the employees, depending on what you want to measure, as well as the context, such as measuring the temperature of an oven or the humidity of a warehouse. In the previous articles, we have been presented with solutions to specific problems, and these problems are overcome by collecting information. Although process control, product tracking and quality are one of the most referenced metrics [7][13][14], others, such as OEE, movement speed, distances travelled, productive and non-productive working time, water pressure were also mentioned in the articles [3][7][8].

Question 3: What frameworks/tools are used to collect information?

Although there are some dedicated frameworks for collecting information [7], there are many other things developed for a given case study, being almost dedicated systems, only developed to respond to a particular problem. These end up having as technological base IOT systems, which collect information and send it to bases of relational or non-relational data through sensors. Thus, the tools to be chosen and mentioned in the studies also end up being dynamic depending on the problem because they try to apply the best technology to which it fits, trying to respond to a particular problem. We can see this in [14], where the main objective was to construct a system in which it was possible to "control and monitor water pipe". For this, an IoT solution was developed that answered this issue.

Question 4: What data analysis and visualization tools are possible and used?

Some tools were indicated throughout the analysis of the studies. Sometimes they were tools and graphics in the framework or application itself, such as Andon systems [3][4]. Others are well-known frameworks in the industrial world, such as PowerBI and Thingsboard [1]. The study by [1] emphasizes the importance of these tools in supporting decision-making. Some of these tools are known and widely used, such as: Tableau; Thingsboard; Plotly; IBM Watson IoT Platform; Power BI; Gephi; Grafana; Kibana Tool; JavaScript libraries, frameworks e toolkits. Some tools can be incorporated into a website [14] using JavaScript or tools such as DevDash [11]. However, today has the same objective: The valorization of the collected data and subsequent treatment and analysis. This type of tool is extremely important because it is through the visualization of the data that we can make decisions or see the system's state for analysis.

III. CONCLUSION

Production control systems are complex. Several technologies can be used, such as the use of contact technologies or the collection of information through sensors, using IoT technologies. In this type of application, it is important for the visualization of information that can be simpler as Tableaux or more complex platforms, such as Amazon Web Services (AWS), integrate into it all the operations. In this type of approach, KPIs are the focus in what concerns the search to improve productivity factors, resulting from metrics and information analysis, also in this field studies refer to several approaches. According to the problem to be solved, IoT can be used, associating platforms for data visualization and analysis that allow productivity to be improved for the situation in question. For future work, we recommend a larger study to tackle the presented limitations in the introduction and to develop a system that combines IoT technologies to support productivity metrics in the industry.

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Emergency Phone Call Alternatives: a Review

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***Abstract*— Emergency calls usually made over a telephone line may have limitations, such as: speech or hearing difficulties of the speaker; impossible verbal communication due to the circumstance (aggression, threat, etc.); difficulty of the call to be established due to location or lack of signal. To overcome these limitations, alternatives must be found. The alternatives have several advantages over the emergency telephone line since they use newer technology and have the advantage that they can adapt to the various circumstances in which the emergency call is made, as well as to the difficulties of the callers. With emergency phone call alternatives, it is possible to address issues such as: sending the exact and up-to-date location of the emergency call as well as sending all necessary information, avoiding the time-consuming questions that telephone operators have to ask, which is crucial for responding to the emergency; carrying out an emergency call discreetly; facilitating the call for help for people with communication difficulties or when verbal communication is not possible; sending information via audio, video, and text. These alternatives have the disadvantage of depending on the use of the Internet for their operation, which with technological advances, tends to be a mitigated problem. A systematic review has been conducted based on Preferred Reporting Items for Systematic Re-views and Meta-Analyses (PRISMA) methodology and the studies address some consistent evidence about emergency telephone line alternatives and how these are an asset to emergency requests and responses, creating knowledge for the development of a digital solution.**

Keywords- Emergency; Application; Mobile; Help; Telephone Line.

I. INTRODUCTION

Generally, requests for help are made only using an emergency telephone line. Because it is a telephone call, it is necessary to have a verbal communication between the caller and the operator, which sometimes becomes a problem due to several factors, such as the circumstances or weaknesses of the caller [1]-[3].

Examples of difficulties in the call for help are: during a robbery, when the robber is nearby; a pursuit; domestic violence or direct aggression; a person with communication difficulties; or others. In these cases, the possibility to verbally communicate with the operator is limited, making the call for help difficult or even impossible. What often happens in these circumstances in a call to the emergency telephone line is that nobody speaks, and the operator is unable to assess the situation and its location, two of the most important pieces of information to send the appropriate help. Another example where the emergency telephone line cannot be used is when dealing with deaf and/or people with disabilities, as they are not able to communicate verbally with the operator, thus always depending on others, if it is necessary to make a call for help. An application where users can make distress calls in situations where verbal communication is not possible or when the conditions for indicating the location are not met, for example, would be the most appropriate solution.

The approach to supporting the development of an efficient solution for the calls for help in these contexts is to carry out a systematic review of scientific studies where the state of the art can be assessed regarding aspects such as: forms of communication in the context of the call for help; information sent; mechanisms and/or computer solutions used and their advantages over the emergency telephone line used in order to support the development of a user-centric system. However, this approach also has some limitations. The literature search was performed only in three scientific databases. This decision may have influenced the number of relevant studies obtained. The use of other databases could possibly have increased the number of studies analyzed and contributed to improving the general analysis, as well as the search strategy, which had restricted the number of non-relevant studies (studies published many years ago, very general studies, studies that do not focus on the research objectives, or studies not written in English). However, these restrictions did not have a significant effect on the discussion and conclusions.

This paper is organized as follows. Section 2 presents the details of the methodology of the systematic literature review. Section 3 describes the strengths and limitations of this work. Finally, Section 4 presents the conclusions and directions for future work.

II. METHODOLOGY

The objective of this work is to analyze scientific articles that contain supporting information for the development of an emergency system as an alternative to the telephone line. The review is reported according to the PRISMA [4].

A. Research questions

Our work aims to address the following research questions.

Question_1: What are the alternatives to the emergency line/other solutions for emergency calls?
Question_2: What mechanisms/computer solutions are necessary or can be used to create an alternative system for emergency calls?
Question_3: What information can/should be transmitted in emergency calls?
Question_4: What are the advantages of alternatives to the emergency phone line?

B. *Inclusion criteria*

The literature studies are selected according to the following criteria.
Criterion_1: Studies between 2016 and 2021.
Criterion_2: Studies written in English.
Criterion_3: Studies in which the full text is available.
Criterion_4: Systems that respond to help requests.
Criterion_5: Systems that use mobile applications, desktop applications and different telephone line technologies for emergency calls.

C. *Search Strategy*

In this the research, the databases *IEEEXplore*, *ACM Digital and ScienceDirect* were used to identify the articles. The set of search terms were: "Emergency Application" AND "Mobile", "Emergency System" AND "Mobile". The research was conducted between November and December 2021.

III. RESULTS

As presented in Figure 1, after the research was performed and criteria 1 was applied, 142 scientific studies were found, 4 from the *IEEEXplore* database, 10 from the *ACM Digital database* and 128 from *ScienceDirect*. Applying criteria 2, as well as the removal of duplicates, resulted in the exclusion of 2 studies. Thus, 140 studies were analyzed based on the title and the abstract, 124 being excluded based on criteria 4 and 5. The full text analysis of the 16 resulting studies was performed and criteria 3, 4 and 5 were applied. The remaining 14 studies were included for review. Data were extracted from all studies identified using a predefined format. Data extracted included: study; year of publication; alternatives to the emergency line; information transmitted; advantages. Table I identifies the extracted data of the included studies. The characteristics of the included studies have been summarized in the following text.

In [5], the authors developed a mobile application that allows making distress calls without looking at the screen phone. The request is made by holding rhythm patterns, such as taps on the screen with the phone, that can be in the pocket, and thus a distress call can be made without others noticing that it has been made. The application allows three features: send an SOS request to a person elsewhere, audio or video recording, and an SOS function that alerts people near you to get help.

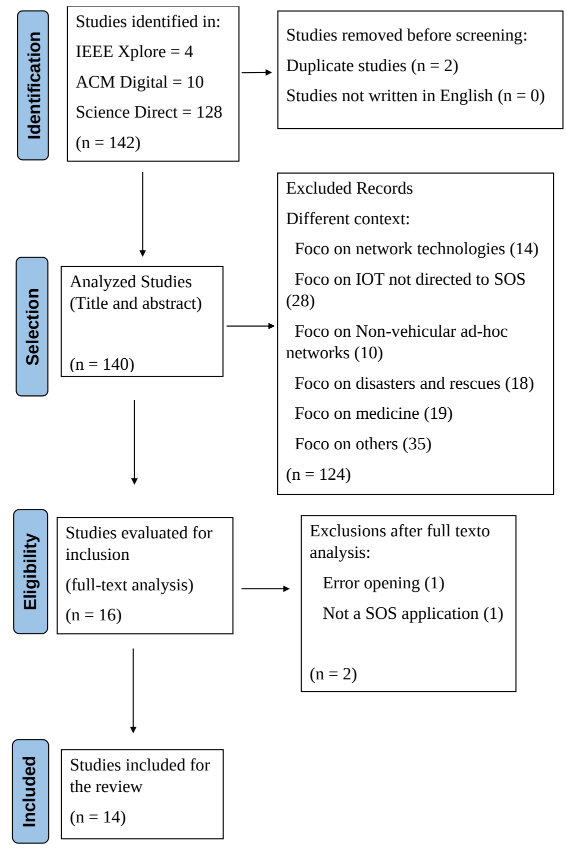

Figure 1. Flow diagram for new systematic reviews (adapted from [4])

TABLE I. EXTRACTED DATA.

Article	Year Publication	Alternatives to the emergency line	Information transmitted	Advantages
An Emergency Application for Smartphones Based on Rhythm Pattern Recognition [5]	2016	Mobile app enabled by touch patterns on your smartphone	Location, audio, video, text	Sending discreet and fast distress calls
A cloud-based architecture for emergency management and first responders' localization in smart city environments [6]	2016	IOT e *cloud*	Location	Easier to locate
Information visualization for emergency management: A systematic mapping study [7]	2016	Computer system	Text	Improves emergency management
Dynamic LTE resource reservation for critical M2M deployments [8]	2017	LTE mobile networks	Text	Receiving data without human intervention

Article	Year Publication	Alternatives to the emergency line	Information transmitted	Advantages
Bangladesh Emergency Services: A Mobile Application to Provide 911-Like Service in Bangladesh [9]	2018	Mobile app	List with emergency services	Allows to consult the available emergency services, their location, and contacts
OpenAlerts: A Software System to Evaluate Smart Emergency Alerts and Notifications [10]	2018	Mobile app	Text, images, location	Allows to inform users that there is an occurrence nearby
Towards a next generation 112 testbed: The EMYNOS ESInet [11]	2018	Emergency calls from the internet	Audio, video, and instant messaging	Allows to make emergency calls over the internet
Modern Mobile Emergency Applications: Fact or Fiction? [12]	2019	Mobile app	Location	Easier to locate help request
Client-based Total Conversation Solution to Support People with Hearing Impairment in Medical Emergency [13]	2020	Mobile application for video-conference	Audio, video	Distress calls from people with hearing impairments
Design and implementation of a Vision Stick with Outdoor/Indoor Guiding Systems and Smart Detection and Emergency Features [14]	2020	Mobile app connected to a cane	Location, text, audio	Guide individuals with visual impairments, and call for help through the cane
Highly-efficient fog-based deep learning AAL fall detection system [15]	2020	IOT and mobile app	Text, location	Allows to alert a care giver that elderly person has fallen
Why do people want to use location-based application for emergency situations? The extension of UTAUT perspectives [16]	2021	Mobile app	Text	Higher performance, more reliable service
Increasing disaster victim survival rate: SaveMyLife Mobile Application development [17]	2021	Mobile app	Location, text,	Allows to visualize disasters on a map in real time and call for help
Crowdsourcing to save lives: A scoping review of bystander alert technologies for out-of-hospital cardiac arrest [18]	2021	Mobile app	Location, text	Faster assistance in the event of a heart attack

In [6], the authors present an emergency management service that uses IoT services and hybrid cloud architecture, the location, and orientation of first responders in emergencies. The service also provides functions for obtaining, storing, and processing various information that is extremely useful for decision-making in emergency response situations. One is the deployment of devices in reference points of an occurrence. Using the rescuers' mobile devices, the system can draw an approximate map of the location, which can be used to identify the space in which the rescuer is moving, supporting movements in unknown rescue locations.

In [7], the authors did a systematic analysis of how researchers use information visualization systems for emergency management. This analysis had important conclusions to be used by researchers, who can then analyze and develop new emergency management systems. The main conclusion was that: map-based visualization is the most used visual tool; emergency response is the phase of emergency management is the most dynamic phase because the tasks performed in this phase are sensitive and executed quickly and the one with the greatest potential to receive technological innovations; databases are the most used data source; and real data, are used more than simulated data. The results of the study thus provide insight into the area studies what helps in the development of technologies to help in the management phases of an emergency. Moreover, knowing the current trends, for example the forms of visualization and interaction in emergency management can be studied and verify if they are the best for the scenarios where they are used. As for the gaps found, such as the authors' proposing not very wide-ranging approaches to emergency management, these are important to help researchers improve them.

The study in [8] presents Machine to Machine (M2M) communications as a technology of high importance in distress calls. Through devices in areas where help is needed, data can be exchanged to respond to the rescue, but to have this sending and receiving of data in M2M communications, they mainly use mobile communications standards where Long-Term Evolution (LTE) is the most used. To use these technologies in emergency environments, it is necessary to ensure that communications are reliable and uninterrupted. So, in this study some techniques (probabilistic resource reservation and prediction-based resource reservation) are needed to dynamically allocate part of the LTE resources for emergencies to ensure that there is no competition in the use of communication resources by the rest of the network and that there is an isolated network part to ensure secure communications.

In the study from [9], the authors describe a mobile emergency application that provides emergency line-like services (991) in Bangladesh. The system provides a dynamic, up-to-date list of all emergency services in Bangladesh. Using Google Maps, users can scan for the location of nearby emergency services, as well as the directions to them. Calls can be relaunched without having to fix the numbers, as these are available in the app.

In [10], the authors present a system for testing emergency notifications. The system allows the creation and testing of sophisticated emergency alert notifications, which can contain various types of information, such as a map with the affected area and the exact location of the user or text informing of an event. This is useful, for example, to notify users that an emergency is occurring in a nearby area.

In [11], the EMYNOS - nExt generation eMergencY commuNicatiOnS project is described, which is an Internet Protocol (IP) address-based platform for emergency services, and the project is funded by the European Commission. This study presents the introduction of IP in emergency systems in Europe, thus will be possible emergency calls, which include audio, video, and instant messaging. This solution is based on the Emergency Services Internet Protocol Network, which is an internal IP-based network and can be shared by all Public Safety Answering Points. With the development of the platform, it is now possible for citizens to make emergency calls from the internet.

The authors of [12] have conducted a study to compare the current emergency applications and emergency phone lines. They described some difficulties and problems of emergency calls. One of the main difficulties identified was a call location and reporting it so a mobile application can solve that problem. They also mention that emergency applications face several problems and some of them can be solved with 5G technology. Finally, they present a developed application, when 112 was dialing a trigger was activated that using the Pan-European Mobile Emergency Application architecture allows sending an emergency message containing the precise location and citizen information. Even if the user is in a different country, the application sends the information to the correct emergency response point.

The authors of [13] present a system that allows people with hearing impairment to request help. The system allows a specialist in communication with people with these limitations, as an intermediary of the conversation having audio and video support to communicate with the person who makes the request, but only provides audio to the emergency center person. This system helps both the person making the request and the person responding to it, to communicate with each other using a specialist in communication with people with hearing difficulties.

In [14], a walking stick is described for visually impaired individuals. This cane allows guiding the individual to defined locations through voice commands and connects to a mobile application using google maps. The walking stick also has a system to monitor obstacles around the individual and provides information on how to avoid them. In addition, it also has an SOS button that, through a Global System for Mobile (GSM) module, sends an SMS to family members or friends with the exact location of the individual if there is no response from any of them, the system calls the authorities through the GSM module.

In [15], a system for fall detection especially suitable for the elderly, is presented. This system is based on Deep Learning and IoT, where there is no button to be pressed in case of a fall but a set of sensors on the users' clothes. When a fall is detected, an alert is sent to the elderly caregiver's cell phone through the application associated with the sensors.

In [16], the authors studied the intentions of the population to use a mobile emergency app in developing countries such as Indonesia. An existing emergency app was used to distribute questionnaires and allowed to analyze some determinants in the use of the app for calling for help, such as performance, trust in the service, social influence, fear of criminal activities, and privacy issues. This study concluded that trust has the most significant impact on the population's intention to use an emergency app. It is since the population believes, in the ability of the app to send the distress message quickly, accurately, and reliably. The concern about personal data collection is the factor that most negatively influences the population to use an emergency app.

The authors of [17] present an Indonesian emergency mobile application for disasters, with a special focus on earthquakes. Disasters in real-time appear in map. For example, in the case of earthquakes, the location and magnitude are indicated. The application has an SOS button that can be pressed by users to call for help. After the user presses the button, the request and its location are sent to the rescuers. The rescuer has a map with the locations of the various distress calls then the system helps to prioritize the calls based on four variables: age, distance to the point of safety, health status, and regional disaster risk.

The authors in [18], conducted a study on applications and systems for alerting of a cardiac arrest. The systems focused on issuing an alert, sending a notification to nearby devices, so that someone who is nearby, and has first aid training, can perform resuscitation maneuvers until medical help arrives on the scene. Some of the systems studied also alerted those who did not have first aid training because even if they did not have such training, they could follow some instructions in the applications or by calling for help. In this study, they tried to identify and characterize these systems, where most are mobile applications that send push notifications to people within a certain radius of the occurrence and through GPS directions guide them to the occurrence. The authors also try to summarize the literature and look for gaps in it, identifying, for example, difficulties in recruiting people to use these applications, because there are still concerns about security and responsibility when responding to these alerts. They also identify the existence of a problem in many countries, related to the guarantee of protection to the citizen volunteers who respond to the alerts, namely in issues related to injuries, or even death resulting from the rescue provided.

IV. Discussion

Based on the results presented in Figure 2, the articles analysed were published between 2016 and March 2021, three articles in 2021 (21.4%), three articles in 2020 (7.1%), one article in 2019 (7.1%), three articles in 2018 (21.4%), one article in 2017 (7.1%), three articles in 2016 (21.4%). Figure 2 shows the number of analyzed articles per year.

Regarding alternatives to the emergency line, in the analyzed studies, mobile applications are the most used for developing alternatives, as illustrated in Figure 3.

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Regarding the information transmitted in the alternative systems to the emergency line, the one that stands out the most is the "text" where 11 studies use it for information communication. Next, "location information" is the most used and the least used, nonetheless, are "images". This analysis is set out in in the graph in Figure 4.

According to the analysis of the 14 studies, it can be concluded that new ways to make emergency requests and new systems to respond to emergencies have been developed. Although there are still several difficulties and setbacks in these new systems, more technological, and that use the internet instead of the telephone line, it is expected that, with the evolution of mobile networks, namely the appearance of 5G, some of these difficulties will be solved. It is also possible to conclude that several emergency systems have been developed focused on responding to specific problems and difficulties that exist in the current emergency phone line, for example, the difficulty in making requests for help by people with verbal or auditory communication difficulties, with visual difficulties, in situations where verbal communication is not possible or in situations where it is necessary to make the request without anyone else noticing that it was made. There is also a search for computer solutions at the technical level, for these systems where there is a focus on the use of the internet of things and cloud computing.

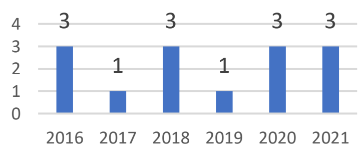

Figure 2. Studies per year

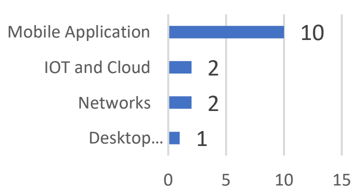

Figure 3. Emergency phone line alternatives

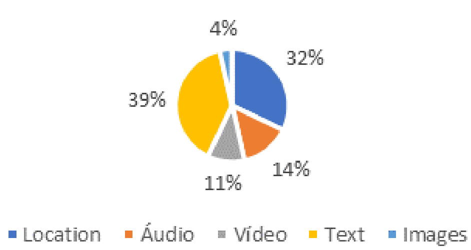

Figure 4. Information transmitted

Thus, from the fourteen articles analyzed, the main conclusions were:

(Q1) What are the alternatives to the emergency line/other solutions for emergency calls?

Mobile applications and computer systems are a great alternative to the current emergency line. These solutions have the advantage of allowing many features, such as: sending the exact and updated location in the distress call; sending distress calls discreetly; sending distress calls facilitated by people with disabilities; and sending information through audio, video, and text - which phone calls do not allow, becoming an asset for the calls and consequent response to them, [5]-[18].

(Q2) What mechanisms/computer solutions are necessary or can be used to create an alternative system for emergency calls?

With the evolution of technology, there is a focus on mobile devices use, the internet of things, and cloud computing systems to create alternative systems for distress calls, [5][6][11]-[13][15][17].

(Q3) What information can/should be transmitted in emergency calls?

With today's technology it is possible to transmit any information needed in a distress call, e.g. audio, video, images, exact location, text, etc., [5][11]-[15][17][18].

(Q4) What are the advantages of alternatives to the emergency phone line?

These new alternatives to the emergency telephone line, by using newer technologies, have the advantage that they can adapt to the various circumstances in which the emergency call is made and to the difficulties of the person making it. Thus, new functionalities are possible, such as

- sending the exact and up-to-date location of the distress call, which avoids the many questions that must be asked over the emergency phone line, which takes essential time for the rescue.
- sending distress calls discreetly, which in certain circumstances is critical, as verbal communication may not be possible or help may be needed without anyone noticing.
- the sending of distress calls made easy for people with disabilities, which prevents them from communicating.
- sending information via audio, video, and text.

In other words, new ways are provided to make requests for help with greater accuracy, detail and speed that were not possible with the emergency telephone line possible [5]-[18].

V. CONCLUSION

With the performed analysis it is possible to conclude that several studies have been conducted to find alternative and viable solutions to distress calls. There are some systems developed however each one has its characteristics and focuses on a particular context.

New technologies have also given an impulse to the development of these new systems because they allow the improvement of the current emergency systems and make them even faster, more accurate, and more accessible to everyone. This presents a benefit to improving emergency response and saving lives. The need to connect to the internet is the major obstacle to these new alternatives, but 5G tends to tackle the problem.

There is a need for systems that allow the communication of distress messages discretely, as well as tracking the route or location of the victim, but no information was found on systems with these characteristics, which shows a research opportunity. Based on the analysis made, the lack of information and support systems for victims would be beneficial to analyze and develop a system that solves this gap for future work.

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A Systematic Literature Review on Technology Acceptance Research on Augmented Reality in the Field of Training and Education

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***Abstract*—Augmented Reality (AR) is an emerging technology that ranks among the top innovations in interactive media. With the emergence of new technologies, the question about the factors influencing user acceptance arises. Many research models on the user acceptance of technologies were developed and extended to answer this question in the last decades. This research paper provides an overview of the current state in the scientific literature on user acceptance factors of AR in training and education. We conducted a systematic literature review, identifying 45 scientific papers on technology acceptance of augmented reality. Twenty-two papers refer more specifically to the field of training and education. Overall, 33 different technology acceptance models and 34 acceptance variables were identified. Based on the results, there is a great potential for further research.**

Keywords—Technology acceptance; TAM; UTAUT; Augmented reality; Literature review; Training and education.

I. INTRODUCTION

AR is one of the top emerging technology innovations in interactive media. Over the past years, AR has found its way into different new application fields. One application area is education and training. AR can connect the digital and physical domains. Based on the technology, scenarios can be built to allow users to interact simultaneously in the real and virtual worlds. When applied to training and education, users can learn more effectively through new ways and methods using AR. Hence, education and training are one of the application fields where AR is applied most [1].

This research paper is about the status quo of the technology acceptance research on augmented reality as technology innovation in training and education. The main objective is to determine the state of research in the field mentioned above. The paper is structured as follows: Firstly, the theoretical background is described in Section II. For this, the terms AR and the theoretical foundation of technology acceptance, as well as is most common research models, are briefly described. Secondly, a systematic literature review was conducted. The scope and approach of this analysis are subject to Section III. The results of the literature review, including a more detailed discussion of the revealed models and variables, are presented in Section IV. The paper concludes with a summary of the findings and an outlook on further research in Section V.

II. THEORETICAL FOUNDATION

A. Augmented Reality

In the following, the theoretical background of augmented reality is explained. The beginnings of the development of AR solutions go back to the 1960s [2]. In scientific literature, Azuma [3] established a definition of AR: "*Augmented Reality (AR) is a variation of Virtual Environments (VE), or Virtual Reality [...], AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world.*" So AR is an extension of reality, not a replacement for it. Furthermore, three key characteristics of AR are defined: Firstly, AR combines reality and virtuality. Secondly, AR is an interactive application in real-time. Thirdly, the content is shown in 3D.

AR is related to Virtual Reality (VR). Milgram et al. [4] imply a representation of this relation. This so-called Reality-Virtuality (RV) Continuum shown in Figure 1 combines AR/VR and introduces Mixed Reality (MR) in between. AR is next to the real environment, Augmented Virtuality (AV) to the virtual environment.

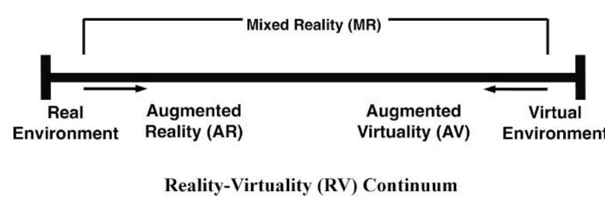

Figure 1. Reality-Virtuality-Continuum [4].

According to Milgram et al. [4], the RV Continuum can be defined as "… *a generic Mixed Reality (MR) environment as one in which real-world and virtual world objects are presented together within a single display, that is, anywhere between the extrema of the RV continuum.*"

In summary, AR can be understood as a way to enhance the users' perception and interaction with the real-world [3]. Although AR was firstly realized over 50 years ago, the use of this technology is still rudimental in both society and the economy. Identifying factors that influence the acceptance and further dissemination of AR is an important research question.

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B. *Technology Acceptance*

With emerging innovations, user acceptance refers to the decision whether to use a new technology or not. Acceptance is a latent construct with different factors influencing the construct. To explain these factors, different research models were developed for a wide variety of systems and applications in various domains [5][6]. The two most influential models of technology acceptance are the Technology Acceptance Model (TAM) by Davis [7] and the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. [8]. Both models are described in the following.

1) *Technology Acceptance Model*

The TAM is the best known and most widely empirically validated model for explaining user acceptance towards technology [9]. The research model was developed by Davis as part of his doctoral dissertation [7] and can be traced back to the Theories of Reasoned Action (TRA) and Planned Behavior (TPB). TRA and TPB are seen as important theoretical foundations of the TAM [7][9][10]. The TAM, including its variables and relationships, is shown in Figure 2.

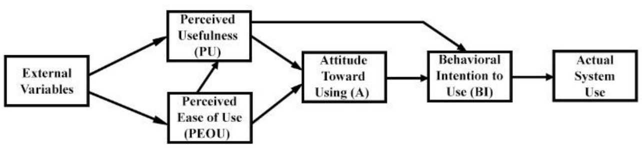

Figure 2. The Technology Acceptance Model (TAM) [10].

Davis assumed that the actual use of a system depends on the *Behavioral Intention (BI)* of the user. BI depends on the *User's Attitude towards Using (A)* and *Perceived Usefulness (PU)*. Together with *Perceived Ease of Use (PEOU)*, the two variables PU and PEOU build the core of the TAM: PU describes *"... the degree to which a person believes that using a particular system would enhance his or her job performance"*[7]. PEOU is defined as *"... the degree to which a person believes that using a particular system would be free of effort"*[7]. PU and PEOU have both a positive effect on the Attitude towards Using. In addition, PU and PEOU are influenced by *External Variables*. Furthermore, PU directly impacts BI [11].

Over the years, the TAM was frequently empirically validated and extended in different ways. Venkatesh et al. published two extended models in the form of the TAM 2 [12] and TAM 3 [13]. Since its introduction 35 years ago, the TAM has become a powerful and robust model for technology acceptance in the field of information systems research [6][9].

2) *Unified Theory of Acceptance and Use of Technology*

Another frequently used model in technology acceptance research [6] is the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. [8]. The UTAUT was developed by integrating the eight most common acceptance-related theories and their variables into a unified model. In the UTAUT, as presented in Figure 3, the three variables *Performance Expectancy*, *Effort Expectancy,* and *Social Influence,* directly influence the *Behavioral Intention*.

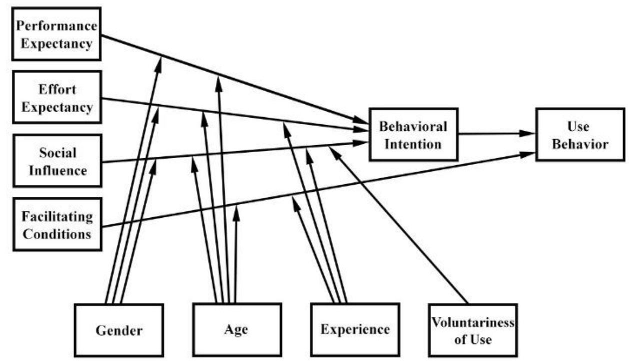

Figure 3. The Unified Theory of Acceptance and Use of Technology (UTAUT) [8].

Performance Expectancy is defined as *"... the degree to which an individual believes that using the system will help him or her to attain gains in job performance"* [8]. This construct is the strongest predictor of usage intention. Furthermore, *Effort Expectancy* is the second construct defined as"... *the degree of ease associated with the use of the system*." [8] The third construct is *Social Influence* which is introduced as *"... the degree to which an individual perceives that important others believe he or she should use the new system"*. The fourth construct, *Facilitating Conditions* represents *"... the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system"* [8]. *Facilitating Conditions* is the fourth main construct of the UTAUT and has a direct impact on use behavior. Additionally, the UTAUT model contains the variables *Gender*, *Age*, *Experience* and *Voluntariness of Use* as moderators, i.e., with moderating effects on the main variables [8].

III. METHODOLOGY AND STUDY APPROACH

A. *Scope of the Study*

Since their release, TAM and UTAUT have become the subject of many research papers. The models have been empirically validated in many different areas. In addition, other variables have been incorporated into the models to reflect the specifics of application environments or systems. The state of research and developments in technology acceptance research has already been the subject of many literature surveys [6][14]-[18]. The goal of all these studies was to provide a general overview of the models and the specific factors influencing technology acceptance. To the authors' knowledge, however, there is no work to date that more comprehensively examines the applied research models for technology acceptance in the field of AR and specifically its application in training and education. Our research aims to fill this research gap and provide a grounding for further analysis. The main contribution of this work is to gain an overview of the different models and TAM/UTAUT extensions, as well as variables applied in this field.

In our the literature review, we examined relevant research on AR technology acceptance according to the following criteria:

- *Research Objectives:* This refers to the aim of the research as well as to the AR systems, applications, and devices that have been investigated in the papers.
- *Sample Data*: Information about the geographic origin of the research and the user groups surveyed in the empirical part of the study.
- *Research Methods*: In addition, the evaluation method used for the models were analyzed.
- *Technology Acceptance Model*: The specific acceptance research model underlying the research.
- *Model Extension and Variables*: Extensions of the original models and corresponding acceptance variables.

B. *Systematic Literature Review Approach*

The literature review was based on a three-step approach, as shown in Figure 4. The objective was to gradually narrow down the articles to the point where research on technology acceptance of AR applications in training and education could be identified. The following seven scientific literature databases have been researched for relevant articles:

- *Google Scholar*
- *Science Direct*
- *Springer*
- *Emerald*
- *ACM Digital Library*
- *EconBiz*
- *IEEE Explore Digital Library*

In the first step, the terms *acceptance* and *augmented reality* were combined to form a search phrase. Only articles containing the search terms in their title were considered. This assumes that the title reflects the focus of the work. In summary, 204 articles were found.

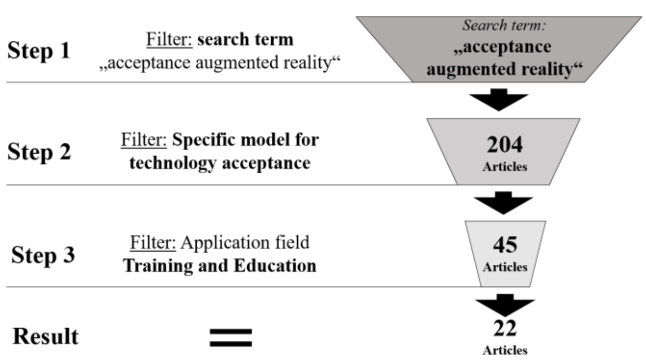

Figure 4. Approach to Literature Selection.

In the second step, all remaining articles were analyzed for referring to a specific technology acceptance model, i.e., the TAM or UTAUT and its variants, resulting in 45 articles.

In the third step, the specific application area of AR in training and application was applied as a filter criterion. As a result, 22 articles matching all criteria and focusing on technology acceptance of AR in training and education could be derived. The 22 articles are listed in Table III (Appendix).

IV. Result of the Literature Review

In the following, the results of the literature review are presented structured on the criteria as discussed in Section III.

A. *Research Objectives*

Ten research articles of the 22 identified have conducted a quantitative study, whereas only two used a qualitative approach. Ten research papers comprise mixed-method studies with quantitative as well as qualitative procedures. This result indicates that technology acceptance research is predominantly quantitative in nature.

Furthermore, the kind of AR device was examined. A distinction was made between mobile devices such as smartphones and tablets as well as AR glasses. Eight articles refer to mobile devices. No article investigated the use of AR glasses. Fourteen research papers did not specify a AR device as a subject of investigation at all.

B. *Sample Data*

Regarding the sample data, the countries of origin were first broken down by continent in which the surveys were conducted. Most contributions (ten papers) come from Asia, followed by seven articles from Europe. Three publications can be allocated to North America, whereas only one paper comes from South America. Two articles are cross-country studies that have conducted surveys in Australia and North America. This shows that most research activities are carried out in Asia and Europe.

C. *Research Methods*

The most popular research method for analyzing the sample data and validate the proposed research models are Structure Equation Modelling (SEM), regression analysis, and correlation analysis. These methods were used seven times in the 22 papers. Other evaluation methods, such as factor analysis, were applied only three times or less. The remaining papers did not provide any information on the evaluation methods.

D. *Technology Acceptance Model*

In this part, the different acceptance models were examined. Furthermore, the original acceptance model on which the articles are based was analyzed. In detail, 18 articles were based on the TAM. UTAUT and its variants built the basis for two articles. Furthermore, four papers did not propose an extension but applied the original models. The original TAM was used three times. The TAM2 was the referenced model in one research article. Another last article did not refer to any existing research model. The research activities show that the TAM is the most frequently used acceptance model, followed by the UTAUT and its successors.

These findings reflect the previous research activities in the field of technology acceptance research. As already mentioned, especially the TAM is extended with different variables. The core components of the original TAM – *Perceived Usefulness (PU)* and *Perceived Ease of Use (PEOU)* have been integrated most. It must be declared that only the main constructs Attitude Toward Using (A), Behavioral Intention to Use (BI) and Actual System Use weren't considered. The third most used variable is *Perceived Enjoyment*. *Perceived Enjoyment* as introduced in TAM3 was defined as *"... the extent to which the activity of using the computer is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated"* [13]. This variable was used in four of the AR acceptance research articles and thus most frequently for an extension of the TAM in all the papers investigated. Thus, the researchers seem to attach particular importance to this factor in the acceptance of AR. The other variables identified were used only very rarely. Against this background, the entire 45 identified AR acceptance research papers will be examined on the variables for a model extension in the following.

E. Model Extensions and Variables

In reference to the scope of this study, the different model extensions and variables are of importance. Thus, the last investigation criteria was applied to all 45 articles, which refer to the acceptance of AR and contain a specific technology acceptance model in all application fields. Of these 45 articles, 33 research articles have made an extension of a technology acceptance model by introducing own acceptance variables. Nineteen of these articles refer to training and education, 14 to other application fields. Figure 5 shows the composition of the article selection.

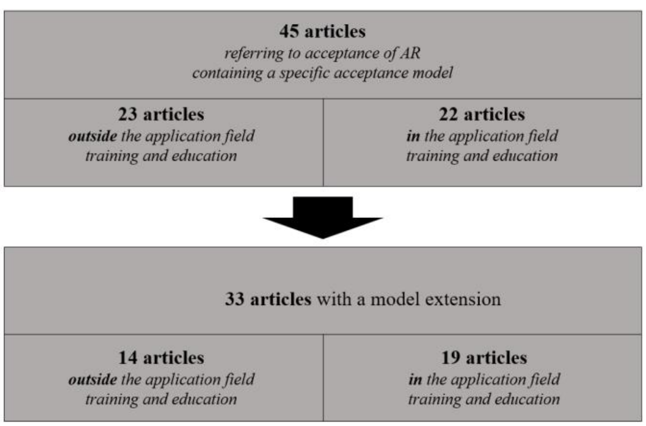

Figure 5. Composition of the article selection.

The following section examines the 14 articles that relate to AR applications in other fields before the model extension on training and education are discussed thereafter.

1) AR Exensions Outside Training and Education

Nine of the 14 articles outside training and education introduced variables on AR acceptance. The other five model extensions used already existing variables. In summary, 18 variables referring to the specific application area of AR were identified. The eight variables *Perceived Interactivity* [19], *Media Novelty* [19], *Previous Media Experience* [19], *Users' Innovativeness* [19], *Recommendation* [20], *Risk* [20], *Playfulness Expectancy* [21], and *Content Relevance Expectancy* [21] are introduced by the authors without providing a more comprehensive definition in the paper. The ten other variables are shown in Table I.

TABLE I. IDENTIFIED AR VARIABLES OUTSIDE TRAINING AND EDUCATION

Variable (Frequency of Use)	***Definition [Source]***
Perceived Benefits/ Relative Benefit (2)	Positive aspects resulting from the use of AR [22][23][24]
Personal Innovativeness (2)	"Users' willingness to try out new services and products" [20][23][25]
Costs of Use (2)	Costs include efforts costs, loss of privacy costs and usage costs [20][23][26]
Self Presentation (1)	"Self-presentation is defined as presenting personal thoughts by using a creative manner of expression" [27]
Information Sharing (1)	"Information sharing refers to the level of willingness to share information with others" [27]
Visual appeal (1)	"Visual appeal relates to the exhibition of fonts and other visual elements such as graphics; it acts to enhance the overall presentation of information systems" [28]
Technology Readiness (1)	An overall state of mind that the user is ready to use a technology [28][29]
Personal Innovation (1)	"Users' willingness to adopt or reject a new technological innovation" [24]
Dimensions of cultural differences (1)	Different cultural dimensions which affect the technology acceptance. Uncertainty, Power distance, Masculinity-Femininity, Individualism/collectivism, and time orientation are summarized to the variable Dimensions of cultural differences [30].
Personality Traits (1)	'Big Five' Personality Factors conscienceless, Openness, Agreeableness, Neuroticism, and Extraversion [30].

The models are extended by the researchers with the aforementioned variables to propose AR acceptance models that are better aligned with the specific conditions of AR applications. The research model of Jung et al. [23] is shown here as an example.

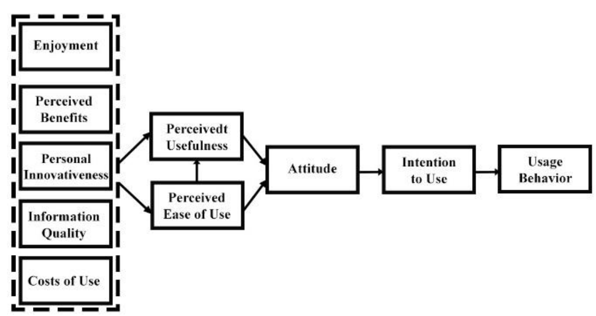

Figure 6. Proposed AR Acceptance Model [23].

The proposed model integrates variables from the TAM [7], IS Success Model [31], and UTAUT [8], as well as new own variables. This proposed research model refers to the application field tourism and urban heritage and represents one model extension as example. The example was chosen because of the mixture of three existing models as well as new variables. Furthermore, the base of the model can be allocated to the TAM as most of the model extensions investigated in this literature survey.

2) AR Extensions in Training and Education

As mentioned before, 19 papers with model extensions were identified for AR acceptance research in training and education. Twelve of these papers proposed research models with extended variables. In summary, 16 AR acceptance variables have been identified in the papers. Again, some papers introduced variables without a more comprehensive definition: *Teaching Experience* [32], *Technology Experiences* [32], *Characteristics of the system* [33], *Information Experience* [34], and *Information Literacy* [34]. One paper [35] proposed an acceptance model introducing *Duration of Use*, *Perceived Exertion*, *Emotion*, *Attachment*, *Harm*, *Perceived Change*, *Movement*, and *Anxiety* as *moderating factors* of AR acceptance. These six variables have not been further defined. In comparison, the other ten of the sixteen variables with their definition can be found in table II.

TABLE II. IDENTIFIED AR VARIABLES IN TRAINING AND EDUCATION

Variable (Frequency of Use)	***Definition [Source]***
Perceived Situation Awareness (2)	Assistance for Understanding the environment around someone [36][37]
Interface Style (2)	Visualization of the AR content [36][37]
Technology Optimism (2)	"… a positive view of technology, including control, flexibility, convenience, and efficiency" [38][39]
Technology Innovativeness (2)	"… a person's inclination to try new information technologies" [38][39]
Visual Quality (1)	"… the degree to which a user considers that the app is aesthetically attractive to the eye" [40]
Ergonomics of AR-platform (1)	"The ergonomics of the ARTP refers to the features related to hardware and accessories that can help students develop favourable (or unfavourable) perceptions regarding the motivational factors." [41]
Resistance to Change (1)	"… attitudinal response of a person *not* accepting an innovation" [32]
Mobile Self-Efficacy (1)	"… an individual's perceptions of his or her ability to use mobile devices in order to accomplish particular tasks" [42][43]
Motivational Support (1)	"External support based on the culture, leadership and environment" [44]
Teachers' acceptance and integration of technology (TPACK) (1)	"… a theoretical framework which includes pedagogical knowledge, content knowledge, and pedagogical content knowledge for teaching. Furthermore, technology knowledge refers to these aspects." [44]

The analysis shows that researchers in the field of training and education are also trying to adapt TAM and UTAUT to AR and the specific application conditions in the field through models with extended sets of variables. However, the low frequency of variable use also indicates that generally accepted extended models have not yet emerged. Rather, the models can be seen as individual attempts to adapt the traditional acceptance models to the scope of the particular study.

Koutromanos and Mikropoulos [42] developed a Mobile Augmented Reality Acceptance Model (MARAM) based on factors to explain teachers' intention to use educational AR applications.

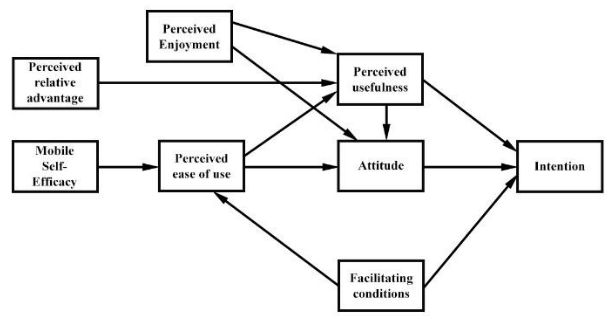

Figure 7. Mobile AR Acceptance Model (MARAM) [42].

In this proposed model, as shown in Figure 7, the acceptance variables introduced for model extension are *Perceived Relative Advantage (PRA)* and *Mobile Self-Efficacy*. PRA refers to the perception of the user whether the MAR Application is seen as better than conventional methods in education. Mobile Self-Efficacy regards the ability to use a mobile device. In addition, existing variables from the TAM variants, such as Perceived Enjoyment and Facilitating conditions, are applied next to the core variables of the TAM.

V. SUMMARY AND CONCLUSIONS

As a result of this literature review, it should first be noted that technology adaptation research in the field of AR is still a very young research field, with relatively few research papers published. Only 45 research articles with specified research models on technology acceptance of AR could be identified. Training and education was the most frequent area of application with 22 articles. With a close look at this field of application, it becomes clear that the papers primarily focus on the field of academic teaching. In comparison, educational applications outside schools and academics, e.g., using AR for training in companies or in industrial environments, show a lack of research.

Concerning the research method, it can be stated that in most cases, quantitative research (parts) were found. Regarding the regions of research, most research activities can be located in Asia as well as Europe. Looking at the research methods, it shows that Structure Equation Modelling (SEM), regression and correlation Analysis are the most commonly

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used methods for statistical analysis in acceptance research examined.

The research models and their extensions have been the focus of this study. The results show that the TAM and its core variables are the most frequently used models and theoretical foundation. Almost all research articles are based on the TAM or its extensions. In addition, the UTAUT and its extension can be stated ad well. Three-quarters of all investigated 45 papers on AR acceptance research with a specified model have made a model extension integrating own variables. In total, 34 AR variables not included in any existing acceptance model and its model variants have been identified. Despite the large number of variables, only a few relate specifically to the technology AR or the application field of training and education.

This study initially focused on the identification of the relevant papers on AR acceptance research and the variables for a model extension. The empirical significance of these variables as influencing factors and their importance in explaining AR acceptance need to be addressed in further research. However, an analysis is only possible for those studies that disclose relevant information on the corresponding statistical analysis.

It can be seen as problematic that researchers seem to focus on producing new models with their own and unique extended acceptance variables instead of contributing to the empirical validation of existing ones. Many of the specific variables found in our analysis are only applied by individual researchers. Thus, there is no generalizable AR technology acceptance model that has yet been sufficiently empirically validated in different application areas. Existing specialized AR research models, such as MARAM, should be validated more comprehensively for application in other contexts. Moreover, there is a particular lack of models that reflect application conditions in the field of corporate training outside schools and academic institutions.

Appendix

TABLE III. IDENTIFIED AR ACCEPTANCE RESEARCH PAPERS ON TRAINING AND EDUCATION

Author (Year)	***[Source]***
A. Balog and C. Pribeanu (2010)	[41]
Y. Wang, A. Anne, and T. Ropp (2016)	[45]
C.-C. Mao, C.-C. Sun, and C.-H., Chen (2017)	[37]
C. Papakostas, C. Troussas, A. Krouska, and C. Sgouropoulou (2020)	[46]
T. Arvanitis, D. Williams, J. Knight, C. Baber, M. Gargalakos, S. Sotiriou and FX. Bogner (2020)	[35]
A. Hamed, K. Manolya and U.S. Nazim (2018)	[40]
J. Iqbal and M. S. Sidhu (2021)	[47]
A. Álvarez-Marín, J. A. Velázquez-Iturbide, and M. Castillo-Vergara (2021)	[38]
E. P. A. Sugara and Mustika (2016)	[48]
L. Ping and K. Liu (2020)	[49]
T. M. M. Alroqi (2021)	[50]
J. Iqbal and M. S. Sidhu (2019)	[51]
J. Ma, Q. Liu, S. Yu, M. Liu, J. Liu, and L. Wu (2021)	[33]
M. Al-Ani and N. Kasto (2018)	[52]
X. Geng and M. Yamada (2021)	[53]
A. Álvarez-Marín, J. A. Velázquez-Iturbide, and M. Castillo-Vergara (2021)	[54]
M. Ibáñez-Espiga, A. Di Serio, D. Villarán-Molina, and C. D. Kloos (2016)	[55]
J. Jang, Y. Ko, W. S. Shin, and A. I. Han (2021)	[44]
G. Banerjee and S. Walunj (2019)	[56]
J.-H. Loand Y.-F. Lai (2018)	[34]
I. Vrellis, M. Delimitros, P. Chalki, P. Gaintatzis, I. Bellou, and T. A. Mikropoulos (2020)	[36]
G. Koutromanos and T. A. Mikropoulos (2021)	[42]

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