How is Action Research Being Used in Computer Science? A Review

Liliam Maria Orquiza, Laura Sánchez García and Bruno Gabriel Costelini

Abstract: A literature review showcasing what specialists who work and publish scientific papers, involving action research in the field of computer science, think and do. It includes the 97 most cited (ten times or more) Computer Science papers that deal with action research, published between 2010 and 2019, and retrieved from *Scopus* and *Web of Science* databases. Specialists in information systems are using action research in various research capabilities, not only in the construction of artifacts, but mainly to improve their communication capacities with users and vice versa.

Keywords: Action research; computer; literature review; research methods

¿Cómo se utiliza la investigación-acción en informática? Una revisión

Resumen Revisión de la literatura que muestra lo que piensan y hacen los especialistas que trabajan y publican artículos científicos relacionados con la investigación-acción en el campo de las ciencias de la computación. Incluye los 97 artículos de informática mas citados (diez veces o más) que tratan sobre investigación-acción, publicados entre 2010 y 2019, y recuperados de las bases de datos Scopus y Web of Science. Los especialistas en sistemas de información están utilizando la investigación acción en diversas capacidades de investigación, no solo en la construcción de artefactos, sino principalmente para mejorar sus capacidades de comunicación con los usuarios y viceversa.

Palabras clave: Investigación-acción; computadora; revisión de literatura; Métodos de búsqueda

1. Introduction

The purpose of a scientific paper is to enhance access to knowledge and, among all types of scientific publishing, it is the fastest formal way of sharing new discoveries of scientists and researchers. Scientific journals, in their turn, beyond fostering the publication of papers, stand also as historical records of the advances in the various fields of knowledge, ensuring a scientific memory of all completed research.

The earliest scientific journals appeared in 1665: *Philosophical Transactions* and the *Journal des Sçavans* (Banks, 2010). Now, 350 years later, *Ulrich's Periodicals Directory:* one of the largest such directories in the world, accounts for over 70 thousand refereed and peer-reviewed journals, 50 thousand of which are available online. Papers published in peer-reviewed journals are generally more respected and recognised, inasmuch as they are eval-

uated beforehand, ensuring some minimal standards of what is published, not only in form but mainly in content (Day & Gastel, 2017).

Such a high volume of journals likewise leads to thousands of papers being published simultaneously, even when one looks at a specific field of human knowledge, it is impossible to access everything that is available. This problem demands some advanced organisational, storing, retrieving and reviewing techniques to manage this mass of knowledge and information that is being produced.

We propose then a discussion of the current state of action research academic publishing, since it is widely known that this is a methodology that lends itself more to actual intervention rather than scientific publishing per se. Also, given the authors involvement with the fields of education, computer science and information technology, our challenge is to figure out how action research is being used in the field of Computer Science. We then seek to identify what are the focus, purposes and results that are being showcased in scientific papers published in peer-reviewed journals, in a timeframe that reaches back over the past ten years.

Although there is no consensus on who came up with the concept of action research, "it has been developed differently for different applications" (Tripp, 2005, p. 445). According to Tripp (2005, p. 445), action research has been used as a general term for four different methodologies: diagnostic research, participant research, empirical research and experimental research. For Tripp, at the end of the 20th century, Deshler and Ewart (1995) identified six main kinds developed in different fields of application, as shown in Table 1.

Table 1 – Fields and applications of action research over time

Field and application	Precursor
In administration	Collier
Community development	Lewin (1946)
Organisational change	Lippitt, Watson and Westley (1958)
Teaching	Corey (1949, 1953) in the late 1940 s and early 1950 s
Political change, conscientization and empowerment	Freire (1972, 1982)
In national development in agriculture soon thereafter	Fals-Borda (1985, 1991)
And most recently in banking, health and technology generation	via the World Bank and others such as Hart and Bond (1997)

Source: Tripp, 2005, p. 445.

Social and human sciences have, traditionally, been the ones that started out using action research. Exact sciences, which used to be removed from it, have since incorporated its use more and more. Our research has revealed that Computer Science, in particular, has increasingly been making use of action research, focusing not only on product development, but also various other functions. We point out that action research has been used, not only in an instrumental fashion but also in a theoretical one, over the past few years, allowing for experts

to develop, each time more socially relevant, collaborative and engaging research (Hayes, 2011, p. 15).

Our concept of *action research* is grounded not only in authors who work with the methodology itself, but also in computer science authors directly involved in action research, be it in a theoretical or in a practical fashion.

The SAGE Encyclopedia of Action Research defines action research as a term that "is used to describe a global family of related approaches that integrate theory and action with the goal of addressing important organisational, community and social issues together with those who experience them" (Coghlan & Brydon-Miller, 2014, p. xxv). In an ongoing cycle of co-generative knowledge, action research allows for collaborative learning and the design, enactment and evaluation of liberating actions through combining action and reflection (Coghlan & Brydon-Miller, 2014, p. xxv).

This definition presents the three main characteristics of action research: integration between theory and practice in an action/reflection cycle; inclusion of the subjects of the research as actors of the research themselves, turning them into co-researchers; and, as a consequence, a collective creation of knowledge. Reason and Bradbury (2008) corroborate that definition, stating that action research assumes a participatory process focused on the development of practical knowledge, mindful of human values. In the words of these authors, action research "seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities" (Reason & Bradbury, 2008, p. 4).

Authors such as Baskerville & Wood-Harper (1998), Davison, Martinsons & Kock (2004), Kock (2007), Suchman (2007), Hayes (2011), Rogers (2012), Papas, O'Keefe & Seltsikas (2012), Mathiassen, Chiasson & Germonprez (2012), Dombrowski, Harmon & Fox (2016) and Staron (2020), among others, are unanimous in pointing out the urgency of carrying out a social reflection on professional practice in the field of Computer Science.

Computer Science professionals must be aware of the social impacts of their profession, seeking to act as transformative agents of society. The issue of digital inclusion is directly linked to social inclusion, hence the need for a transdisciplinary approach when we tackle the matter, integrating Social Sciences and Computer systems, which are inherently tied to Exact Sciences logics. Bridging both fields of knowledge is essential for including technological and social aspects. And action research, as we see it, has the necessary components for the Computer Science professional to direct his practice towards making up a more just society.

Rogers (2012, p. 65–66) draws our attention to studies directed to address human values,

> getting to grips with life goals (cf. to user's goals), such as how people can pursue healthier, more meaningful and enjoyable lifestyles; and probing technology's underbelly as it becomes more insidious; including looking at how governments and organisations have become more reliant on computer technology to control society while individuals have started to use it in more criminal ways, making people worry more about what information is tracked, analysed and stored about them.

Rogers (2012) ponders that it is possible to be a participant and a researcher at the same time, collecting ethnographic materials for publishing and coming up with the theoretical construction, and at once looking to making the world a better place. The author posits there ought to be a balance between research and development, and "new theories should be viewed in the wider context of the researcher's social responsibility*"* (Rogers, 2012, p. 67).

Hayes (2011), in a paper titled *The Relationship of Action Research to Human-Computer Interaction*, posits action research is an explicitly democratic, collaborative, interdisciplinary process. For this computer science scholar "the focus when conducting AR is to create research efforts 'with' people experiencing real problems in their everyday lives not 'for', 'about', or 'focused on' them". She concludes by stating that the action research methodology "focuses on highly contextualised, localised solutions with a greater emphasis on transferability than generalisability" (Hayes, 2011, p. 17).

Staron (2020), in his book *"Action Research in Software Engineering"* highlights that, while the focus of other research methodologies is turned toward observation, learning and evaluating, action research, besides strongly considering learning, focuses more on intervention and in the context. Staron (2020, p. 16) compares action research, experiments and case studies, and concludes that action research can be dimensioned for problems larger than those of experiments, introducing "changes to its context and at the same time contribute to theory-building" (Staron, 2020, p. 16).

Rogers (2012, p. 66), again, in his book on Human-Computer Interaction (HCI), a recent field within Computer Science developed from the early 2000 s, defines action research as "one such socially responsible approach that is being promoted in HCI", for allowing it to tackle "the empirical, philosophical and moral investigation of technology", opening the way "for a different kind of value-driven agenda".

Hence, the designer's toolbox is then complemented by the implicit knowledge of people who are being impacted by the proposed changes. A project is thus built based on the interaction with the public and, just like in action research, they are furnished with resources that allow them to act in face of any current issues. Kock (2007, p. 20), furthermore, points out that researchers in the Information Systems community have started to show interest in the potential of action research as a tool for Computer Science.

The authors of the 97 papers under discussion here, who have approached action research as their main theme or as a methodology, argue that action research, as a critical approach, allows for research that seeks to improve the practice and realities where such practice takes place.

As highlighted by the authors under review, action research poses a challenge to the conventional wisdom of academia, as it proposes a critical participation which, as mentioned, engages those who might have been subjects to the research (target audiences) as co-researchers. Action research, as a manner of doing research, contradicts practices of unequal and nondemocratic political economic and social systems, challenging the statement of a positivist view of science and promoting the idea of socially built knowledge (Brydon-Miller, Greenwood, & Maguire, 2003), starting from a position of change *with* others (Reason & Bradbury, 2008). The stages to be followed in action research draw a spiral, going through cycles of action and reflection, in a systematic manner. During the action cycles, researchers collect evidence, watch and take note of practices. During reflection cycles, everything that makes sense to the collective is registered and systematised, and from there the next actions are planned. In this way, action and reflection make up the knowledge of the whole which is built in a collaborative and representative way (Reason & Bradbury, 2008).

We believe that, by describing what authors are writing, by charting and identifying tendencies, this paper may serve as a contribution to the discussions on the position of Computer Science in relation to the new fields where action research is now emerging, show

whether it is concerned with how to address multiple challenges emerging across fields committed to transformative change (Wittmayer, Bartels, & Larrea, 2021).

With this in mind, we seek to answer how the field of computer science has been making use of action research, with which purposes, goals and to what degree, by analysing a set of recent scientific papers, from the past ten years, which deal with action research in the field of computer science, seeking to find out who is publishing, where, with what focus and with which goals and results.

2. Methodological Procedures

The keyword "action research" was searched in two databases of scientific and technical information: *Scopus* and *Web of Science* (WoS). Through an exhaustive search in both databases, we sought to determine the reach of papers, as well as to visualise distinctive characteristics and trends in the field. As delimiting criteria, we chose to retrieve papers that were cited ten or more times, between the years of 2010 and 2019. The search strategy was the same for both databases, and can be described thus: 1 – applying the English keyword, under quotes: "*Action Research"*; 2 – In *Scopus*, searching through "*Keywords"* (which looks at keywords provided by both the author and the indexes), and on *Web of Science* searching for "*Topic"* (which allows for searching both the title and abstract, as well as the keyword provided by authors and indexes); 3 – Filtering by the following timespan: from 2010 to 2019, ten years in all; 4 – Filtering by document type: papers only; 5 – Filtering by field of knowledge: computer science; 6 – The results retrieved so far were the reordered, from top cited to less cited, excluding those with less than 10 citations; 7 – Reference date for retrieval was 7 August, 2020.

The search strategy on *Scopus* resulted in the following sentence: [KEY ("Action Research") AND DOCTYPE (ar) AND PUBYEAR >2009 AND PUBYEAR <2020 AND (LIMIT-TO (SUBJAREA, "COMP"))].

On *Web of Science* the resulting sentence was: [TÓPICO: ("action research") / Refinado por: TIPOS DE DOCUMENTO: (ARTICLE) AND CATEGORIAS (computer science cybernetics; computer science information systems; computer science interdisciplinary applications; computer science software engineering; computer science theory methods) / Tempo estipulado: 2010–2019].

It is important to note that on *Web of Science* the field of computer science presents subcategories beyond the five mentioned above. Those five correspond to the ones that the indexing database returned results for in this time span of 10 years that was searched.

In Table 2 it is possible to verify the number of retrieved objects at each stage, in each of the databases, *Scopus* and *Web of Science*, on 7 August, 2020. The following set of papers was identified: 80 papers retrieved by *Scopus*, plus 59 retrieved by *Web of Science*, totalling 139 scientific papers.

However, when the results were compared, it turned out 31 papers appeared on both databases, reducing thus the final count to 108 papers.

Table 2 – Quantitative Results of Action Research Review / Computer Science, on 7 August 2020, through *Scopus* and *Web of Science* Databases

STEPS	SCOPUS	WEB OF SCIENCE
(1º) Search for "Action Research" on "Keywords" field (Scopus) and on "Tópico" (Web of Science)	9.128	15.068
(2º) Search filtered for timespan: 2010 a 2019	6.033	10.562
(3º) Search filtered for material type: papers only	4.545	7.943
(4º) Search filtered for field of knowledge: Computer Science papers only, ordered from top cited to less cited	281	176
(5º) Total papers retrieved, excluding those with less than ten citation	80	59

Source: Research data.

Following this, all papers were retrieved, downloaded, read, analysed and their metadata organised and systematised. Reading the papers allowed us to realise 11 of them did not fit our selection criteria because either they did not belong to the field of computer science, or they only made use of the "action research" keyword without really substantially dealing with the subject. Excluding those 11 papers, the final set of papers was down to 97.

Using a spreadsheet, each paper was catalogued, drawing not only the metadata, but also the following information: research problem, objectives, methodology and results/conclusions from authors. Then, each paper was categorised according to the following contexts of action research application: (1) applied to education/learning, (2) applied to health, (3) applied to businesses/enterprises, (4) action research applied in communities and (5) action research applied to the public administration (either at municipal, state or federal levels). Papers that exclusively theorised action research were gathered in a sixth category: (6) theorising action research.

The comparative analysis of the papers allowed for identifying compatibilities, convergences, as well as trends among specialists who publish papers related to action research in the field of computer science.

Following the search protocol described in Table 3 (presented below), in brief we retrieved the following numbers: 97 papers were cited ten times or more (all on them in English), involving 257 authors, representing 139 institutions from 35 countries. The 97 papers were published in 58 journals. Although the analysis was extended from 2010 to 2019, the year 2019 did not return any paper with ten or more citations.

Table 3 – Data Retrieval and Analysis Protocol

PROTOCOL	DESCRIPTION
Main objective	To analyse a set of recent scientific papers, published in the past ten years, involving action research in the field of computer science, looking to find out who is publishing, where, with what focus and with which objectives and results.
Databases	·*Scopus.* ·Web of Science (WoS).
Types of materials	Peer-reviewed scientific papers only.
Timespan	Papers published between 2010 and 2019.
Keyword	"Action Research".
Retrieval date	7 August, 2020.
Exclusion criteria	·Papers that do not substantially engage with action research; ·Papers which do not belong to the field of computer science; .Papers with less than ten citations in the timespan of ten years.
Search fields	·On *Scopus: "Keywords"*. ·On *Web of Science (WoS)*: "Tópico".
Selection procedure	Reading through the whole paper.
Cataloguing of selected papers	Besides identifying metadata, for each paper the following summary information was gathered in a spreadsheet: research problem, objectives, methodology, results and authors' conclusions.
Paper classification after reading and analysing	Each paper was classified according to the context where action research was applied: 1) applied to education/learning; 2) applied to health issues; 3) applies to businesses/companies; 4) action research applied to communities; 5) action research applied to public administration; and, 6) theorizing on action research.
Analysis procedure	Identifying concepts, definitions of action research and their application to the field of computer science.

Source: The authors.

3. Data Results and Analysis

3.1 Top cited papers

The paper titled *"Action Design Research"*, by authors Maung K. Sein, Ola Henfridsson, Sandeep Purao, Matti Rossi and Rikard Lindgren, published in 2011, counted at the time of this retrieval, 7 August, 2020, 753 citations on *Scopus* and 371 on *Web of Science.*

In their paper, Sein, Henfridsson, Purao, Rossi & Lindgren (2011) argue that, when it comes to design research in information technology (IT), the issue is the focus. According to those authors, IT design researchers turned themselves to artifacts, ignoring the fundamental component that is the organisational analysis in which the artifact is contained, drawing attention to the fact that every IT design project emerges from an interaction with their organisational context. To solve this problem, the authors propose *design action research* as a new research method for their field, placing the organisational intervention at the center. For the authors, a solution to this issue requires a design research method that seeks to come up with IT artifacts in an organisational context and, at the same time, to learn with the intervention by approaching a problematic situation. The design action research emphasises the influence of the relevance cycle resulting from an explicit orientation to combine the construction, intervention and evaluation of a conjoined research effort. In their paper, the authors, besides justifying the need for a new design research method, also describe their principles and stages.

Table 4 presents the top 10 cited papers, by number of citations.

Table 4 – Number of Citations for the top ten cited Papers dealing with Action Research in the field of Computer Science. Data retrieve 7 August, 2020, via *Scopus* and *Web of Science* Databases

PAPER	Scopus	WoS
Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action Design Research. *MIS Quarterly:* Management Information Systems, *35(1)*, 37 – 56.	753	371
Chatti, M. A., Dyckhoff, A. L., Schroeder, U., & Thüs, H. (2012). A reference model for learning analytics. *International Journal of Technology Enhanced Learning*, *4(*5 – 6), 318 – 331.	273	—
Sedlmair, M., Meyer, M., & Munzner, T. (2012). Design study methodology: reflections from the trenches and the stacks. *IEEE Transactions on visualization and Computer Graphics*, *18(12)*, 2431 – 2440.	—	203
Kohler, T., Fueller, J., Matzler, K. & Stieger, D. (2011). CO-creation in virtual worlds: the design of the user experience. *MIS Quarterly:* Management Information Systems, *35(3)*, 773 – 788.	214	140
Puhakainen, P., & Siponen, M. (2010). Improving employees' compliance through information systems security training: an action research study. *MIS Quarterly:* Management Information Systems, *34(4)*, 757 – 778.	—	168
Hayes, G. R. (2011). The relationship of action research to human-computer interaction. *ACM Transactions on Computer-Human Interaction*, *18(3)*, 15 – 20.	191	98

PAPER	Scopus	WoS
Bengtsson, F., & Agerfalk, P. J. (2011). Information technology as a change actant in sustainability innovation: insights from Uppsala. *Journal of Strategic Information Systems*, 20, 96 – 112.	122	60
Cochrane, T. D. (2010). Exploring mobile learning success factors. *ALT-J, Research in Learning Technology*, *18(2)*, 133 – 148.	83	—
LeRouge, C., Ma, J., Sneha, S., & Tolle, K. (2013). User profiles and personas in the design and development of consumer health technologies. *International Journal of Medical Informatics*, *82(11)*, e251-e268.	—	97
Smith, S., Winchester, D., Bunker, D., & Jamieson, R. (2010). Circuits of Power. *MIS Quarterly:* Management Information Systems, *34(3)*, 463 – 486.	77	43

Source: Research data.

We must first point out that not all the papers are indexed by both databases.

Why does Stein et al. (2011) stand out so much above all the other papers in citation numbers?

The main topic must probably be taken into account as we search as answer to this question, given Stein et al. (2011) present a valid discussion on the implications of this research method to information systems (IS), stating that action research tries to combine theory with an intervention by the researcher, seeking to connect theory to practice, and thinking to doing, in an iterative process based on refining working hypothesis through repeated cycles of investigation. On the other hand, other factors may have contributed to this large lead, for instance the exposure period of the paper ahead of others, since it was published at the beginning of the timespan of this review, 2011.

Another point that may have made a significant difference in the number of citations is the multinationality of the authors, and the great number of institutions represented. Supporting the publication of this paper are seven distinct institutions from four different countries: Norway, Sweden, United States and Finland, elevating the scope of the communication networks and, consequently, the spread of the paper.

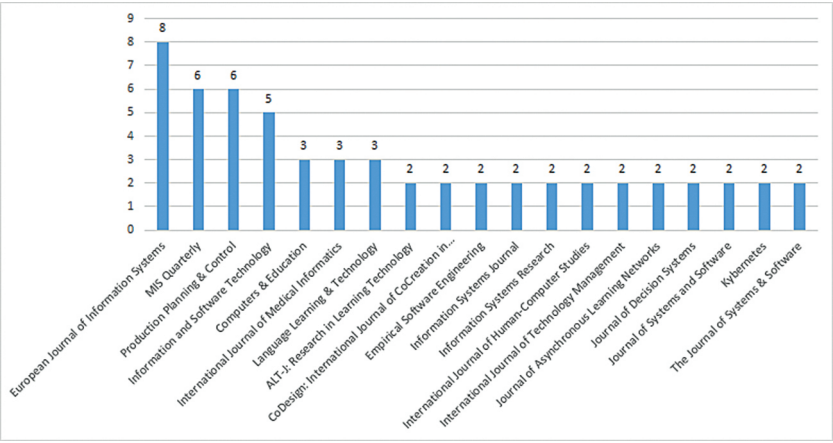
3.2 Top authors and journals

Our 97 papers under analysis were authored by 257 researchers. In terms of authors per paper, we identified that 25% of the papers were written by four authors. Those 97 papers with 10 or more citations, the amount of co-authored papers is much larger than those authored individually, since 79% were co-authored, and only 21% had only one author.

As to authors who have penned multiple papers involving action research in the field of computer science in the decade between 2010 and 2019, only Lars Mathiassen, from Georgia University, in the United States, wrote three papers. It turns out that of the 257 authors involved in the production of those 97 papers under discussion, only 13 others appear in two papers, which comes down to 5% of the total. The other 243 authors, 94% of the total, have produced a single paper.

19 journals that have published two papers or more (58 papers) are presented in Chart 1. 39 other journals were responsible for publishing a single paper, among those top-cited ones.

Chart 1 – Scientific Journals by Number of Papers published involving Action Research in the field of Computer Science, retrieved from *Scopus* and *Web of Science* Databases, 7 August, 2020.



Source: Research data.

Taking into account the scientific journals that are most represented in this literature review, we identified the *European Journal of Information Systems* as top publisher in the field, with eight papers in all.

From Chart 1 it is also possible to identify a core number of scientific journals in the field of computer science responsible for a large number of papers (five or more) involving action research: *European Journal of Operational Research*; *MIS Quarterly; Production Planning and Control* and *Information and Software Technology.*

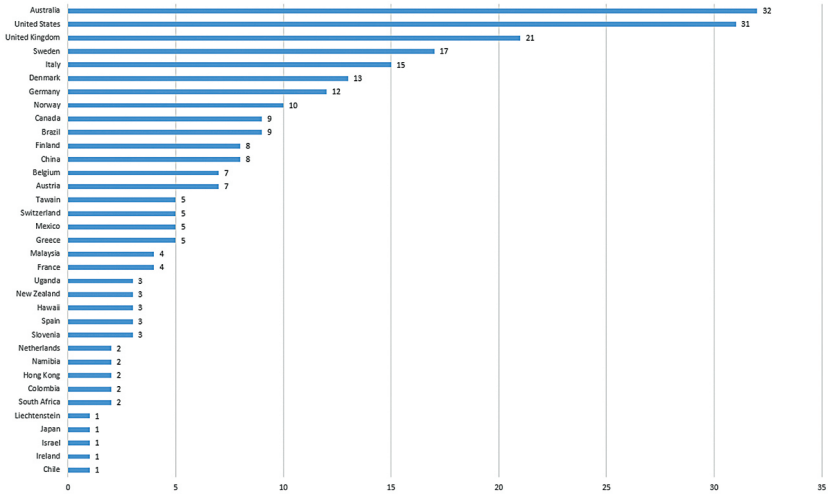
Although *MIS Quarterly* is responsible for four of the top ten most cited papers in this literature review (see Table 4), including Stein et al. (2011), the top cited one, the other three journals, *European Journal of Operational Research*, *Production Planning and Control* and *Information and Software Technology*, stand out due to their continuity and regularity in yearly publishing throughout the decade.

3.3 Top countries

From this set of papers under review we identified the origins of each author, coming up with 35 represented states. Australia, United States, United Kingdom, Sweden and Italy are the top countries among the 257 authors from the 97 papers under analysis. Australia and the United States, with 32 and 31 authors respectively, stand well above third place, the United Kingdom, with 21 authors. Sweden and Italy, in their turn, occupy fourth and fifth positions, with 17 and 15 authors, respectively. Three other countries, with ten or more authors are also worthy of a mention: Denmark and Germany, with 13 and 12 authors respectively, and Norway, with 10 authors total.

Brazil appears tied with Canada, both with nine authors. China and Finland are right behind, with eight authors each, right ahead of Austria and Belgium, with seven authors each. The final score for all countries can be glimpsed from the data tabulated in Chart 2.

Chart 2 – Number of Authors per Country



Source: Research data.

Regarding the fact that the United States appears second place in our ranking, we highlight this quote by Kock (2007, p. xxi), revealing that in that country "estimates suggest that action research accounts for less than one percent of all IS research. The lion's share goes to experimental, survey, and case research".

In the preface of his book *Information Systems Action Research*, the editor draws attention to the fact that often "action research is seen as a research approach that has been originated outside the United States, that has little to do with the American research tradition, and that is largely unrelated to the development and funding of research in the United States" (Kock, 2007, p. xx). According to him, the US has a research tradition more epistemologically geared towards positivism.

Kock (2007, p. xx) states also that "in fact, in a number of disciplines (including information systems), action research finds a lot more acceptance in academic circles outside the United States than within. Some notable examples are England, Scandinavia, and Australasia".

This last statement ratifies the data we found, since our top countries come from those regions, Scandinavia, Australasia, both represented in our ranking of authors' origins, with Australia occupying the top spot.

On the other hand, Kock himself (2007, xx) notes that although "action research" was coined by a German researcher, Kurt Lewin, Lewin actually moved to the United States in 1933, after obtaining his PhD in Berlin, working for years at the University of Iowa, and then

at the Massachusetts Institute of Technology, becoming a pioneer of action research in that country also.

Kock (2007, p xx) in a text written at the dawn of the 21st century, states that researchers in the IS scientific community began showing more interest in the potential of action research as tool for their field, highlighting the name of Richard Baskerville, who Kock deems "perhaps the most prominent figure in the IS action research community today".

Based on Kock's statement, it is possible to infer that, in these 14 years that separate his book's release from today, clearly the use of action research within the computer science field has increased in the United States.

3.4 Top institutions

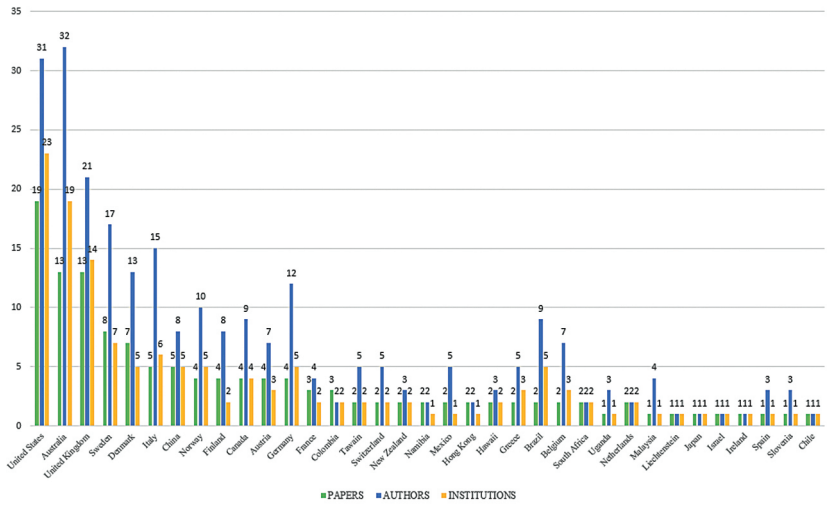
Regarding the institutions to which authors belong to, we also find some clusters of action research in the field of computer science. Of the 139 institutions authors affiliate themselves with, 14 count four or more authors, making up 10% of the total. A single institution counted seven authors, the Blekinge Institute of Technology, Sweden, across three different papers

The intersection between countries and institutions behind the action research papers in the field of computer science shows that Australia and the United States lead quantitatively, with 21 institutions each. They are followed by the United Kingdom, with 13, Sweden and Germany, both with eight, and Denmark, Italy and Norway, each with six institutions.

As is the case of the most cited paper, by Sein et al. (2011), we must point out that a single paper may be associated with authors from various countries and institutions.

Chart 3 presents cross-section between number of papers, authors, institutions and countries of origin.

Chart 3 – Cross-Section between Number of Papers, Authors, Institutions and Countries of Origin

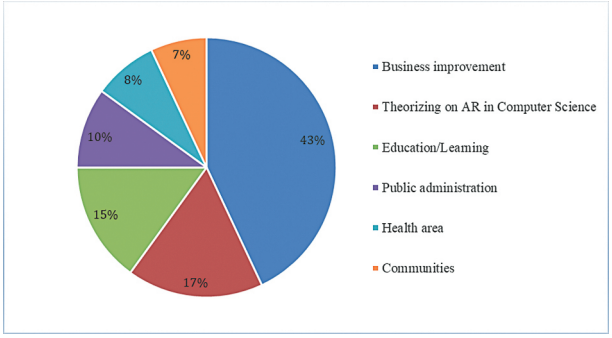


Source: Research data.

3.5 Paper distribution according to the applications of action research

Regarding our classification of papers according to the contexts of application of action research in computer science, results from in order of application are the following: 43% of papers used action research to improve business; 17% theorised about action research in computer science; 15% described action research being used for education/learning; 10% applied action research to public administration; 8% applied it to the health area; and 7% described action research applied to communities, as shown in Chart 4.

Chart 4 – Share of Papers per Application



Source: Research data.

In the set of papers under review, the majority of types of application of action research are associated with improving information systems, software or processes within businesses and industry. We highlight the following topics: "co-creation experience of avatars in virtual worlds", "improving employees' compliance through information systems security training", "'IT Conflict-Resistance Theory': action research during IT pre-implementation", "adoption and implementation of lean thinking in food supply chains", "business-IT alignment and software architecture analysis techniques supporting the engineering of enterprise-wide service-oriented systems", "SPI implementation mechanisms", "risk calculations in the manufacturing technology selection process", "developing trust in virtual software development teams", "forecasting defect backlog in large streamline software development projects and its industrial evaluation", "implementation of the business, system and technology models of the Zachman framework", "eliciting user requirements using Appreciative inquiry", "knowledge management through Enterprise Content Management (ECM) platforms", among others.

Another data point worth highlighting from our set of papers is the 17% index of those emphasising a theoretical approach on the issue of action research in the field of computer science. All of these papers assume that the action research methodology, regardless of the peculiarities in procedures or denominations, is in fact an effective method for computer science professionals.

The application of action research to communities, although present in a smaller rate of 7% of papers, deserves to be highlighted as well for grasping the emancipatory role of this type of research, which assumes changes in behaviour and attitude. Social contexts assume

social actors who are embedded in environments with particular values and sociocultural habits, which must be respected when developing, utilising and/or accepting ICTs (Information and Communication Technologies). Among the seven papers identified as part of this category, one deserves to be singled out, "*Altering participation through interactions and reflections in design*", by authors Winschiers-Theophilus, Bidwell and Blake (2012).

In his paper they relate an action research carried out in a rural community of Southern Africa, reviewing the existing concepts of participatory design to finally propose what they call "transcultural design", aiming to better serve cultural diversity. The authors mention that, in the aforementioned community, participatory practices are already deeply culturally rooted, even though they are in a technologically disadvantaged position. They then sthe indigenous rational structures, such as those of Southern Africa, "require" the comprehension that the discourse is rooted in as paradigm of complete connection of all, expressed in their saying that *a person is a person among other people*" (Winschiers-Theophilus, Bidwell, & Blake, 2012, p.167). This paradigm is based in a type of African philosophical tradition (Bantu), identified as Ubuntu, meaning *humanity.*

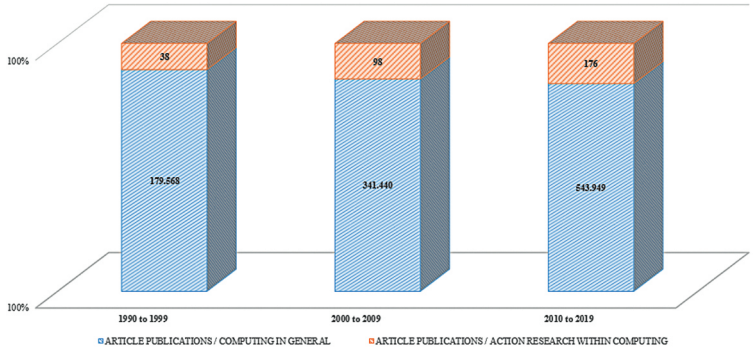
They highlight also that the main thing to understand the African view is to recognise their point of view, embedded in the collective thinking that "I am because we are; and once we are, therefore, I am […]. Thus, Ubuntu is in itself a critical discourse that builds personality through collectivism and, generally, recognises relationships with ancestors inside the collective" (Winschiers-Theophilus, Bidwell, & Blake, 2012, p.167).

The authors are alert that, by rigorously adhering to the set of methods of Participatory Design, one may erroneously believe that participants share a common understanding of participation, and of the roles of participants. One must however recognise the complexity of the connections, and take into consideration local values and sociocultural habits the guide interaction protocols. If such a posture is not adopted, significant underlying tensions will remain regarding relations between democracy, empowerment and participation. Democracy, they postulate, is an explicit goal in the development agenda and, with few exceptions, is associated with specific communication protocols and methods to allow local acceptance, property and domestication of ICTs (Winschiers-Theophilus, Bidwell, & Blake, 2012, p.167).

3.6 Amount of research papers on Action Research

Looking into the past three decades we are able to ratify the fact that indexed papers in the field of Computer Science using the keyword "action research" have been surging. Even if still incipient, there is a clear jump in the number of publications between the 1990 s and 2010 s, as shown in Chart 5.

Chart 5 – Appearances of "Action Research" keyword in Computer Science papers indexed by *Web of Science:* comparison of the past three decades:



Source: Research data.

However, as identified by Avison, Davison, & Malaurent (2017, p. 1) in their paper (which is one of the 97 under review here), in the last few years the number of papers has been beneath the expectations. And just as they highlight, we are not discussing here "the relevance of action research as a research method in the information systems (IS) discipline is not disputed" (Avison, Davison, & Malaurent, 2017, p. 1), but the number of action research papers, especially when compared to the total amount of papers in Computer Science.

They suggest some myths and barriers associated with publishing action research within Computer Science, e.g.: action research is difficult to publish in leading IS journals; action research requires a lot of time and resource investment; action research is inappropriate for Ph.D. students; and, action research is considered to be less scientific than other methods.

As alternatives to help overcome those issues, Avison, Davison, & Malaurent (2017) suggest promoting action research as an appropriate approach within Information Systems, by emphasising the qualities of this methodology, highlighting that it can and must be carried out with scientific rigour, that it has "potential for theory building and testing", as well as being pertinent for graduate-level research. "Divorce from practice is not a desirable outcome in an era where the practical relevance of research is increasingly being recognised, appreciated, and indeed expected" (Avison, Davison, & Malaurent, 2017, p. 7).

4. Discussion and Conclusions

Regarding the number of papers published in the past ten years (2010–2019) and indexed by *Scopus* and *Web of Science*, we conclude that the production of action research in the field of Computer Science is still not expressive, but shows a growing tendency, which is rising.

The authors under review highlight that action research is being carried out in different types of investigation, not only as an aid to the construction of artifacts, but mainly to improve their communication ability with users and vice versa. The focus of action research, in-

variably, leaves the artifact behind and locks in the user and their context, hence the fact that Human-Computer Interaction appears with such strength in the papers under review.

As to the number of papers published by each author, our review identified only one author with three publications. Regarding the countries with most papers, Australia and the United States appear in a virtual tie in terms of the proportion of authors doing action research in computer science, which puts Australia in a position of a scientific hub in the field.

In the initial phase of this literature review, after identifying the databases and doing our first reading of the selected papers, we found out that some of the papers did not have enough characteristics to be classified as research action papers, even if the authors themselves used it as a keyword. This fact raises the possibility that there is still room for discussing what is and what is not considered action research in CS. Perhaps a further enquiry of those authors could reveal other understandings and point new directions and novel approaches. On the other hand, we suspect many researchers who in fact use action research methodologies may have been left behind in our searches for not evidencing their use of the term, thus losing the potential of being read by their peers.

The theories and practices related in the 97 papers under review show the broad range of possibilities for employing this method, be it in isolation or associated to other interpretative types of research methodologies. We believe that, once further reviews identify, evaluate, approximate, compare and solidify the behaviour of researchers/actors, a consistent basis will be built, in order to advance scientific knowledge and, therefore, the number of publications.

This research sought to find out how action research has been incorporated into the field of computer science. The idea was to shine a light on what is being published in terms of scientific papers in the area, looking to support better decision-making and investment in research, besides allowing for a broader view of the efforts of the scientific activity in this theme, highlighting which aspects are more or less explored.

Regarding action research in the field of computer science, theory and practices showcased in the 97 papers under review evidenced the range of possibilities in employing such a method, either by itself or associated with other methods of interpretive research. We believe that as more literature reviews continue to identify, evaluate, compare and contrast, consolidating the behavior of researchers/actors, a consistent basis will be built, contributing to the advancement of scientific knowledge. Such was our purpose in this paper.

Among the authors under review, the application of action research within communities deserves to be highlighted, as it approximates the emancipatory eyes of action research towards changing behaviours and attitudes, as pointed out earlier in this paper.

Rohde, Brödner, Stevens, Betz, & Wulf (2017, p. 166), in their paper titled "*Grounded Design – a praxeological IS research perspective*", argue that human actions and social contexts are moved by complex expectations and interpretations, making their results contingent, unpredictable and nondeterministic. They add that ITCs artifacts, such as algorithm machines are incapable of dealing with that.

Suchman (2007, p. 179), on his turn, highlights that humans make use of an ample set of "linguistic resources, nonverbal and inferential, to find intelligibility in actions and events, to make their own actions sensible and to administer issues of comprehension that inevitably come up".

The aforementioned authors highlight the fact that social contexts are not stable or fixed. Rather the opposite: social actors build and rebuild their social contexts through their own actions and social practices. (Rohde, Brödner, Stevens, Betz, & Wulf, 2017; Suchman, 2007).

In sum, social contexts assume social actors who are embedded in environments with local values and sociocultural habits, which must be respected when developing, using and/or accepting ITCs. Action research, as seen thus far, takes all of this into consideration, showing itself thus as an invaluable tool to help advancing and developing a more effective and just field within Computer Science.

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The Authors

Liliam Maria Orquiza is a Doctor in Informatics, Master in Library and Information Science and Bachelor in Library Science. She has accomplished two specializations at Ryerson Polytechnic University, Toronto (Canada): Distance Education Course Design and Development, and Information Systems and Networks and Services. She has acted as a Professor in various higher learning institutions, both in undergraduate and graduate programs, including in distance learning, and is experienced in Information Science, with an emphasis in Technological Information Systems. In her doctoral thesis she has carried out research in the fields of Science Popularization and Action Research. She currently works as Librarian/Documentalist at the Center for Marine Studies, Universidade Federal do Parana, Brazil.

Laura Sánchez García is a Doctor in Computer Science, Master in Informatics, and Full Licentiate in Mathematics. She has participated in the National Research Network, and Information Society programs of the Brazilian National Ministry of Science and Technology. She has represented Brazil as a Natural Language Processing consultant in the Universal Network Project of the United Nations University. Retired as Full Professor from the Informatics Department of Universidade Federal do Parana, she now leads the "Interaction Design for Inclusion and Social Development" research group, and is an active researcher in the "Scientific Computing and Free Software Center". She has carried out action research in both groups since 2005. She has worked in the field of Computer Science, with an emphasis in Human-Computer Interaction and Education Informatics.

Bruno Gabriel Costelini is a Library Assistant at the Center for Marine Studies, Universidade Federal do Parana, Brazil, and PhD candidate in Law at Durham University (United Kingdom). Trained as an Oceanographer in Brazil, and a former Science Without Borders fellow at Cornell University and Harvard University, his research has moved from the Natural Sciences to the History of Science, Science Communication and Science and Technology Studies. His upcoming thesis on the role of science in the regulation of deep seabed mining draws from multiple methodological approaches, including participatory and ethnographical studies.