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Assessing Barriers and Facilitators to Evidence Use in Decisions

A Tertiary and Interview Study

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ABSTRACT

Context. Decision-making is a significant step in development process of software engineering. Evidence-based Software Engineering has been one of the strategies attempting to facilitate decision-making process. It follows process of gathering suitable evidence in the aim of making a viable use the evidence.

Objectives. In this study, evidence use in practice was mainly focused as a part of which barriers and facilitators concerning it were aspired to be obtained from the practitioners. Concerning existing evidence, it was also aimed in finding out and gathering the existing evidence in software engineering, as a contribution to the evidence use in practice.

Methods. To obtain the outcomes for the specified objectives, an extensive tertiary study and 18 interviews were conducted. The tertiary study was replication of study by Kitchenham et al. [1]. It was also an updated version for the years of 2010 to 2016. The interviews were conducted among the software practitioners from several types of industries and regions.

Results. 67 SLRs were analysed and extracted to gather and obtain existing evidence. 18 interviews were conducted among software practitioners to assess barriers and facilitators to evidence use in making decisions.

Conclusions. We conclude from results of tertiary study that the research studies in every sub-domain are available under software engineering and are even increasing year by year. From the analysed results of the semi-structured interviews, it was clear that the implementation of research results in practice is inter-dependant on many major as well as trivial factors concerning the practitioners.

Keywords: Decision-making, Evidence, Evidence-based Software Engineering (EBSE), Tertiary study, Interviews, Barriers, Facilitators.

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1 INTRODUCTION

Software development is a process which involves constant decision-making [2]. The existing complex automated operations in software organizations are leading to number of alternatives [3]. The existence of number of alternatives raise the need for decision-making. High cost on errors and continuous environment changes make decision-making a complex task in software engineering [2]. An individual making decisions has to deal with number of criteria, each resulting to either positive or negative consequences with high uncertainty levels [4]. The probability of each consequence is assessed and the decision is made considering the favourable consequence with high probability [4]. Probabilities provide quantification of evidence which handle uncertainty during the process of decision-making [4].

The topic of decision-making has been focus of researchers belonging to various domains since many years. As described by Herbert in 1959 study [5], a decision depends upon many facets such as values, environmental facts, and the conclusions drawn from those values and facts. The outcomes of decision-making play a major role in the success of software development [6]. The significant factors such as speed, cost and quality depend upon the type of decisions made in the process of software development [6]. As there are various viewpoints and opinions from various stakeholders, the problems concerned with decision-making are complicated [6]. The complexity involved in decision-making is also due to high dependency on human factors such as relationships, knowledge and culture [7]. There is a lot of uncertainty and knowledge insufficiency involved in most of the decision-making [6]. It can be perceived from the survey results of Thesis by Ree [8], that expert opinions, web forums, social media, industrial conferences and newspaper are the mostly referred sources for decision-making. Whereas, scientific conferences and scientific journals rank the least from the survey results. It is seen from this study that practitioners consider resources from internet such as blogs or videos to gain knowledge and deal with uncertainty of decision-making in software engineering practice on a regular basis. These sources might contain trivial information which might not have been tested for practice and was not rigorously obtained either. Whereas, the results obtained from academic research are outcome of research performed under controlled setting with real data in a rigorous approach. Therefore, the evidence, from the research results, obtained by researchers is more valid, trustworthy and can give a greater support for decision-making.

There are many studies dealing with existing evidence to collect, modify and make it useful in practice. A study [9] from 2003 worked to provide a framework that can gather evidence pertaining to particular decision. They have also worked on tackling uncertainty in decision-making [9]. A further exploration in this area led us to concept of Evidence based software engineering (EBSE) from a study by Kitchenham et al. [10]. Kasoju et al. [11] worked on exploring the field of automotive software test process to obtain the experiences in evidence based approach implementation, and also the challenges and their appropriate solutions involved in it. They explored on implementing EBSE approach in an industrial case, and they described EBSE as the process that uses thorough research outcomes to solve real world issues [11].

The collection of existing evidence is one of the good solutions for facilitating decision-making in software engineering. Implementation of EBSE method can help in enhancing decision-making [12]. EBSE facilitates in decision-making process by providing gathered and analysed evidence from research outcomes and industrial experiences [13]. EBSE promotes the use of combination of existing research

evidences and practical human experiences and values for improved decision-making in software development [12]. It suggests a continuous learning approach with application of evidence together with the existing practical knowledge and experience [12]. This is because it is easier for humans to adapt procedures through experience than from theoretical methods like books, teachers, manuals, colleagues or business partners [12].

Kitchenham et al. [10] provided five steps of EBSE in their study obtained from steps of evidence-based medicine, which are:

1. Obtaining the question from the evidence requirement,
2. Attain the most appropriate evidence for the question
3. Perform deep assessments on it to check its validity, impact and applicability,
4. Provide an expository reflection of the evidence on how would it answer the question and also fulfil the requirement for which it was obtained, and
5. Finally record the effectiveness and efficiency involved in carrying out these steps, and modify to refine the process.

This interesting method of EBSE stirred up the thought of existing evidence which can be implemented for decision-making in practice. This raised the question on what evidence is existing in software engineering research and how would it be processed to be finally implemented. Existing studies have been explored to gain knowledge on these aspects, the overview of what has been perceived from the studies is represented in Figure 1.

Figure 1: Research to Practice Process

The studies dealing with step 1 of Figure 1 are mentioned in this paragraph. A 2005 workshop report [14] has mentioned that there has been plenty of evidence existing but no study was performed to show the evidence from gathered work. Brereton et al. worked on conducting a systematic literature review [15], in 2007, to gather research evidence under software engineering. Number of SLRs (Systematic Literature Reviews) were conducted later, which gathered and provided the existing evidence in various areas. They were collected and analysed by Kitchenham et al. in a tertiary study [1] in the year 2010, which was updated in 2011 [16]. Kitchenham et al. [1] provided a catalogue of existing evidence for benefiting practitioners as well as researchers. The updated version [16] covered research literature till December 2009. Since there have been many studies done to collect existing evidence, the assessment of the research to practice gap needs to be done.

In a study done on Off-The-Shelf (OTS) components [17], it has been stated that there has been research done in the field however, there exists very less implementation and usage of the suggested procedures in industry, showing a gap between evidence and practice. As the research proceeded, such existing problems and issues related to research and practice gap were perceived through different studies. The major problem seemed to be the differentiation existing between the researchers and practitioners in their way of thinking. One of the major drawbacks specified by Santos et al. in their study [18] were regarding the industrial relevance, implementation of the SLR results, and less accurate usage of synthesis methods in gathering evidence.

Zelkowitz et al. [19] consider people from research and industrial domains as two different distinguishable communities, especially in the process of technology transfer. Their work mainly aimed for gaining good understanding on these two communities and to obtain their dissimilarities [19]. In their study, there was a "disconnect" perceived between the research community and the industrial community, which disabled the thoughts, concepts and outcomes from research to be smoothly transferred to industry [19]. The priorities and approaches differ between research and industry, and the topic focused by researchers may not benefit the industry in reality [19]. This is because industry requires a fast profitable production than improving the process for better quality, and researchers focus on the topics of their choice than the ones relevant to industrial benefit [19].

In the context of gap between researchers and practitioners, Misirli et al. [20] listed out few challenges they have faced when they started going forward in conducting their research among the software companies. They mentioned that regardless of their trials and effort spent on clarifying the difference in research and company needs, there was difficulty faced in getting company's complete understanding [20]. They also observed that most of the misunderstanding between researchers and practitioners arose from inconsistent terminology [20]. Therefore, the evidence existing from academia research needs to be processed to implement in practice as represented in Figure 2. This process of synthesizing evidence for implementation is commonly known as knowledge translation in the domain of healthcare.

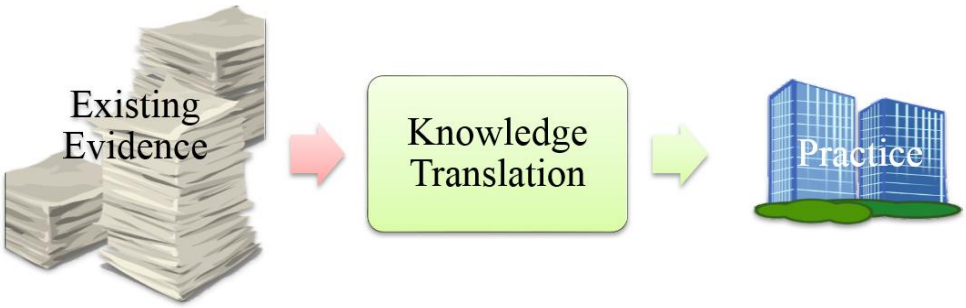

Figure 2: Evidence to Practice

Knowledge translation has been defined by the Canadian Institutes of Health Research (CIHR) as the steps consisting of synthesizing, disseminating and exchanging of the existing research evidence to make it usable for achieving better health system [21]. Similar concepts of knowledge translation have been under extensive research in the domain of software engineering, which is detailed in the following paragraphs.

Garousi and Felderer have mentioned in their study [22] that there is lack of communication between the researchers and practitioners in Software Engineering. They have found out through their study that the gap between researchers and practitioners is due to differences in their perceptions and ideas. They have suggested that initiation from both the communities is required to promote effective collaboration. A 2008 study [23], about research influence on practice in software engineering, mentioned that effective implementation of research requires collaboration of all participants including major contribution from researchers, as it was observed that a continuous regular collaboration among researchers and practitioners lead to utmost implementation of research in practice. They stated that research takes at least about a time of 10 years to manifest in practice as research outcome must transform from its initial stage to applicable stage.

Perry et al. [24] mentioned that empirical studies had no good success in the domain of software engineering though their method was to simply obtain conclusions from observations and beliefs [24]. They have referred several literatures to specify the unusual outcome and peculiar nature of empirical studies in software engineering [24]. It might be due to the factors such as time, uniqueness of software projects, or practitioners' behaviour [24]. Hence, they comprehended that the main purpose of the studies conducted is not fulfilled [24], which shows a gap between research and practice. They have finally perceived that working on modifying established developmental processes of organization involve higher level of difficulty than carrying out individual studies [24]. Therefore, it can be perceived that the research work from academic side cannot be directly understood and implemented by practitioners. Perry et al. [24] argued that the studies should be refined to obtain desirable outcomes for improved situations.

Segal [25] also raised the difference in issues considered by researchers and industrial practitioners. The difference was explained by mentioning an example of difference in type of evidence suitable for practitioner and researcher. The evidence required to convince a manager to implement real-time modifications differs from the evidence that provides in-depth knowledge to the researchers. Therefore, the evidence highly required for practitioners is the one obtained from practical implementation, such as case studies. The research questions in the study revolved around the concepts of the impact of empirical software engineering outcomes on industrial practice. The study also involved thoughts about the reasons behind the inability to apply empirical research outcomes in practice, if it is due to the difference in the domain, or the flaw in empirical studies. The drawbacks concerned with laboratory experiments in software engineering were given, and the author recommended industrial case studies as the best suitable method in the field of software engineering to reduce research to practice gap.

A study [12] of 2005 expressed that a successful coordination and promotion of closer relation between research and practice is what EBSE mainly aims for, so that research would be of use to practitioners enabling inclination of practitioners towards research. Having this as the goal, the study [12] mentioned that though the evidence is obtainable, the doubtful mindset of the software practitioners towards quality of the evidence and it's applicability has been a drawback. These issues have been analysed and sought to be addressed by researchers in the later years. A study [26] from 2008 reviewed the significant models that are capable of evaluating quality of each primary study to obtain a general score on overall strength of body of evidence. Through these studies, it can be perceived that the steps of Figure 1 are a part of knowledge translation process. Knowledge translation consists of two main parts: knowledge dissemination and knowledge exchange [21], which is represented in Figure 3. Though both steps require initiation and collaboration from both researchers as well as practitioners, knowledge dissention involves major contribution of researchers and knowledge exchange requires major contribution from practitioners.

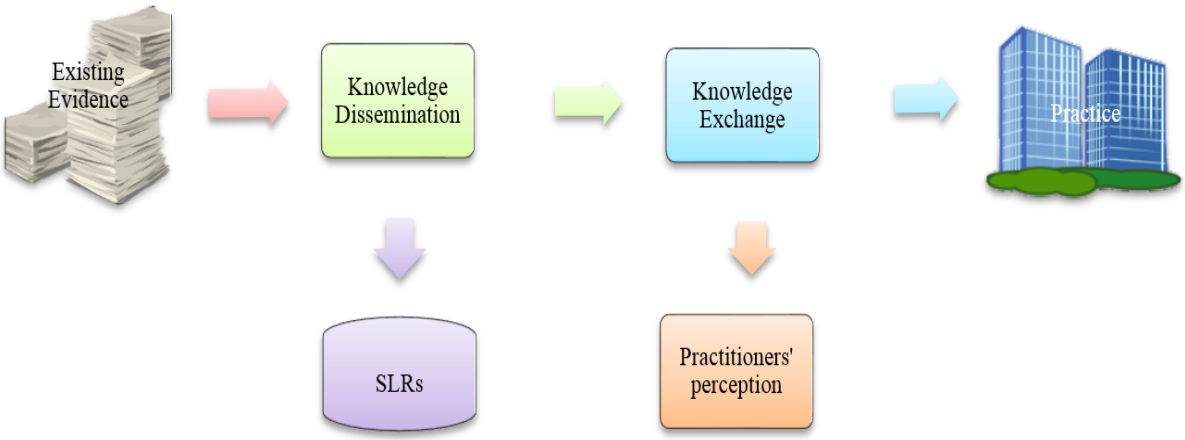

Figure 3: Steps of Knowledge translation

Knowledge dissemination is also called as knowledge transfer and it involves making the research evidence fit for practical implementation [21]. Therefore, it involves steps of understanding the practitioner needs and ensuring that appropriate research is conducted for meeting those needs. Knowledge translation involves ensuring that updated systematic reviews are available for research evidence to be successfully implemented in practice [27]. Therefore, though these concepts have been taken from healthcare domain, they can be implemented in software engineering domain. As it can be seen from study [15] by Brereton et al. that the process of systematic review in software engineering has similarities with that in medicine.

A Systematic literature review was carried out in 2005, which evaluated the nature of empirical software engineers [28]. They have argued that the gap between researchers and practitioners might be reduced by gaining better knowledge of empirical software engineers [28]. Forward and Lethbridge, in 2008, worked on proposing a taxonomy that facilitated software practitioners in decision-making by enabling them to determine the relevance of research results [29], this study's contribution was towards the step 2 from Figure 1 and also towards knowledge dissemination as represented in Figure 3. EBSE process involves gathering evidence from the existing studies, and it is popularly done using SLRs [18]. Kitchenham et al. in their study [30] from 2010 specified that SLRs play a vital role in EBSE. As seen from the literature, one can perceive the significance of SLRs in EBSE, hence the preliminary goal of this study is to conduct a tertiary study to collect and update evidence from SLRs in software engineering replicating the study by Kitchenham et al. [1] for the updated period of 2010 to 2016, as a contribution towards knowledge dissemination.

Knowledge exchange, on the hand, is defined as the process of resolving issues between researchers and decision-makers (or practitioners) in a collaborative fashion [31]. It is done to facilitate in decision-making for a practitioner by showing the applicability and relevance of the existing evidence [31], which directly deals with the practitioners' perception on the evidence. Wohlin, in his study [32], listed out ten challenges faced in collaborative work of researchers and industrial partners. The differences between a researcher and industrial partner have been shown. It was mentioned that industrial partners are less enthusiastic about research as they would have systematic separated agenda [32]. This facet led us to explore the related studies based on practitioners' perception on software engineering research which is mentioned in the remaining part of this section.

According to 2015 findings [33] from experiment in Microsoft, 71% of practitioners were favourable towards software engineering research studies. An updated study [34] was conducted by Carver et al. which also concluded that practitioners have favourable perception towards empirical software engineering and measurement (ESEM) research. In addition, they have found out that industrial influence has no effect on ratings of the papers. Irrespective of the positive perspective of the practitioners on research, 2016 findings [35] from Microsoft survey results showed that practitioners' beliefs are formed through experience than research evidence. It has been also evident from the existing research studies that practitioners have seldom regarded research in practice.

Cartaxo et al. pointed out in their 2016 study [36] that practitioners seldom use research studies for decision-making process. The study [36] also mentioned that reasons behind this might be relevance issues as even a strong research might not be straightaway relevant or suitable for practice. They discussed about the existence of inevident beliefs among practitioners which raise the need of strong evidences and their awareness. They have stated in their discussions that researchers and practitioners desire to transfer knowledge but it is not practiced. Therefore, they have generated evidence briefings in their study contributing to knowledge transfer area.

A 2009 thesis work [8] by Ree has concluded that majority of the practitioners do not regard research for decision-making and they treat industrial and academic research as one. It has been also stated that practitioners consider analysis, experts' and intuition more than research. The study [8] focused on consideration of research by practitioners in decision-making. A survey among the Norwegian Java users' group was conducted in the thesis [8] to obtain the practitioners' perceptions, obstacles in applying research and suggested topics to be focused by researchers.

In the context of existing gap between research and practice, the study on health care [38] has been found, which was an update of study from 2006 [39]. The authors worked on obtaining barriers and facilitators from existing evidence by conducting a systematic literature review. They aimed in improvement of the decision-making for health professionals. Motivated by the healthcare study, the research goal was formulated to use of existing evidence for facilitating decision-making in software practice.

As mentioned in the study by Perry et al. [24], the types of successful research studies of other fields had no good outcome in software engineering and hence, it showed an essential requirement for new types of research studies for software engineering practice. From these literature, the benefits of using existing research evidence could be clearly seen as it would help in decision-making and also help in reducing the gap between research and practice. Therefore, inspired from the healthcare study [39], from which these research issues have emerged, the similar concept of assessing barriers and facilitators was followed but for evidence use in software engineering to facilitate decision-making.

Therefore, interviews were conducted among software practitioners to assess the barriers and facilitators involved in evidence use in practice. So that not only barriers and facilitators are gathered but it also gives us scope to perform in-depth investigation on knowing direct perception of practitioners on the type of research outcomes desired and sought by them.

2 RELATED WORK

A study [4] from 2014 emphasised on Bayesian networks being a suitable framework for gathering evidence, which would be useful for decision-making. They have seen Bayesian decision-making as one of the applicable methods for evidence-based decision-making in software engineering [4]. This is mainly due to the potential of Bayesian networks in handling various kinds of evidence [4]. Another study [40], from 2016, focused on synthesis of evidence using Bayesian approaches. The goal of the study [40] was knowledge use in practice. They have given clear demonstration of synthesis and translation of knowledge through Bayesian approaches using software engineering research examples in their study [40]. They have also analysed and provided benefits and shortcomings of synthesis using Bayesian approaches [40]. The outcomes of these studies directly deal with facilitating knowledge translation area which is shown in Figure 2 of previous section.

Garousi et al. in their recent work [41] of 2017 worked on industry-academia collaboration. They have focused on obtaining practitioners' opinions on software testing which is quite similar to the authors idea of approach in this thesis. One of their research questions was also on finding out the challenges but focusing on the software testing activities in industry [41]. The difference was in their specific focus on software testing and also the method of conducting online survey to obtain practitioners' opinions [41].

The work of Garousi and Felderer [42] involved same problem of research and practice gap but with focus on software testing. Their work [42] also mainly involved exploring the dissimilarities in the focus of the two groups, and also provided recommendations for improvement.

Cruzes and Dybå in 2011 conducted a tertiary study [43], which is the similar research method used in this study, but they implemented it for exploring various systematic literature reviews (SLRs) in software engineering concentrating on the challenges faced in synthesizing research. They explored and looked into types of synthesis methods from SLRs to provide enhanced perception on the challenges for progression of empirical and evidence-based research in software engineering [43]. They also noticed that the majority of the systematic reviews were scoping studies, which could be beneficial in either finding the gaps in the evidence or to spread the gathered research findings, but their excessive existence among the studies shows lack of empirical work as fundamental evidence of these studies is usually complicated [43].

There are also few studies among the relevant literature which solved nearly similar research problems that the authors of this thesis have focused on using almost the same research methods but they differed in few other aspects. The healthcare study by Légaré et al. which has been mentioned earlier, performed a systematic review in the field of healthcare domain [38]. They focused on barriers and facilitators of implementing shared decision-making in the perspective of health professionals [38]. Their topic, idea and methods were something that inspired us to follow a similar approach in the domain of software engineering which led us to conduct this study.

Zhang and Babar, in their study [44] from 2011, worked on facilitating software practitioners in decision-making of software technology selection. Their goal was to set up a body of knowledge with empirical support to promote the effective usage of SLRs in software engineering [44]. They have collected evidence to provide addition to knowledge on various methodological aspects and logistics incorporated in the

procedure of SLRs in software engineering [44]. They have stated at the end that SLRs have gained high attention for gathering evidence in software engineering [44]. This study [44] was updated with an extended version [45] in 2013 adding nine new aspects such as (1) additional description of research method; (2) updated tertiary study up to 2010; (3) updated impact analysis; (4) reported effectiveness of SLRs; (5) reported review types; (6) reported quality assessment and roles in SLRs; (7) updated related work providing comparisons with the latest tertiary studies in software engineering; (8) a thorough discussion on the study conclusions; and (9) improved data presentations.

Similar studies have been performed by Garousi et al. [37] in 2016 and Ree [8] in 2009. The study [37] has conducted a SLR in two phases by performing a systematic mapping study and systematic literature review in each phase. Their focus was on industry-academia collaboration (IAC), and they have tried to obtain proposed IAC models, challenges of IAC mentioned in studies, and the best practices proposed for IAC [37]. This study [37] has also been a motivation for coming up with the question of barriers and facilitators in evidence use.

Ree [8] has conducted their thesis, which is quite close to the research gap that the authors have come up with in this study. In this study [8], a survey has been conducted among the managers of a software industry from Norway. It was done to understand the significance of research among practitioners, the sources used by them for using new techniques, the obstacles faced in using research, and also to know the practitioners' recommended topics for researchers [8]. The obstacles or the challenges obtained by Ree [8] is similar to the barriers that this study has aimed to assess. As a survey has been conducted by Ree [8], in this study, the authors aimed to conduct interviews among software practitioners to obtain in-depth explanation with detail reasoning for each barrier and facilitator mentioned by them.

The thesis work [8] by Ree is from 2009, the loopholes of which presumably seem to be addressed in the later studies. But a recent 2016 work [37] by Garousi et al. still focused on identifying challenges and best practices to reduce gap between industry and academia, for managing risks and following well-prepared practices in the implementation of projects. They suggested that researchers and practitioners can utilize these challenges and best practices in making decisions on organizing their collaborations. The outcomes of their work facilitate the entire process of knowledge translation.

The obstacles obtained in the study [8] were hectic schedules with deadlines and lack of personal time which prevent from implementing research. Although, time might seem as a constraint for not considering evidence, if practitioners are able to see the benefits of cost (in terms of time), then they might consider the evidence. Therefore, our aim is to explore in-depth perceptions about this aspect by obtaining the details from practitioners. The study [8] has also shown that even those practitioners with deep interest in research are not able to implement it in practice. We also would like to explore the reasons behind this by directly approaching the practitioners.

The most recent studies by Garousi et al. [46], formulated completely similar type of research question as this thesis and implemented a close research method. They formulated their research questions to analyse the effect of each challenge obtained in the 2016 study [37] and to assess their success. They have worked on collecting the opinions from researchers and practitioners, hence conducted an opinion survey [46]. Though the method of capturing opinions is quite close to gathering practitioners' perspectives, they [46] conducted a survey and collected the required results using Likert scale, whereas the work in this thesis involved semi-structured interviews to gather the perspectives. Ivanov et al. in their recent study [47] completely focused on

the gap between research and practice but conducted a survey among software engineers.

Since the time this study has been initiated, the relevant literature has been frequently referred at every step to gain more and more understanding of the findings and the insights in this area of research. There have been few studies initially found which were very close to the topic of this thesis and they have been a motivation for the formulation of the research questions and the methodology selection. Nevertheless, as the authors of this thesis moved forward, they have come across more studies quite similar to the study that they have been working on, they have been used for further refining this study. Among the relevant studies referred, there were few studies that worked on same problem that this thesis focused but using different research methods and a few on different research problem but similar method.

Even after coming across most recent studies regarding the issue of research and practice gap. One can clearly perceive that the problems still exist regardless of the number of solutions proposed by researchers. The most recent studies ([41], [47], [42]) have also had the central topic revolving around the research and practice gap. They even mentioned issues between academia and industry such as no good collaboration [41], no motivation for collaboration [46], difference in areas of focus [47], and no adequate communication [42]. Hence, the gap between research and practice is still big [47], therefore this study is presented which can contribute to the industry by providing evidence obtained from research attempting to reduce the gap and also help in reducing uncertainty in decision-making. Also with the barriers and facilitators for research use in decisions for successful decision-making in industry.

3 METHODOLOGY

The main aim of this study was to facilitate effective use of evidence from existing literature. Therefore, in this study, interviews with experienced software practitioners were conducted to obtain barriers and facilitators from their perspective on implementation of academic research results in decision-making. Parallelly, to obtain a summary of existing evidence, a tertiary study was conducted, which is a replication of the Tertiary study by Kitchenham et al. [1] for the updated years of 2010 to 2016. The procedure for conducting the Tertiary study was directly implemented from the steps given by Kitchenham et al. in their study [1].

3.1 Research Questions

The overall goal of this study is to promote the use of academic research results in software industries. Therefore, each research question was formulated as an endeavour to achieve the main goal.

RQ.1) What evidence exists in the research literature to facilitate decision-making in software industries?

This question was formulated aiming to collect the existing evidence which can help in refining the interviews to obtain accurate information. As mentioned before, this was achieved by conducting a tertiary study, by replicating the study by Kitchenham et al. [1]. The details of the tertiary study are explained further in the sub-sections 3.2, 3.3, 3.4, 3.5 and 3.6.

RQ.2) What are the barriers hindering the utilization of the evidence in practice, if any?

RQ.3) What are the facilitators that help in implementing intervention in practice, if any?

RQ.2 and RQ.3 were formulated to obtain the barriers and facilitators of research evidence use in practice. This was accomplished by conducting interviews among the software practitioners. This was performed to capture their direct and straight forward opinions and perceptions on academic research results. Further details of the interviews are given in the sub-sections 3.7 and 3.8.

3.2 TERTIARY STUDY DESCRIPTION

There are various definitions of evidence, and evidence can be said as the knowledge acquired from the results of the replicable observations or experiments that are performed achieving the present-day approved design, execution and analysis standards [48]. This evidence from various studies is usually captured and summarized in Systematic literature reviews (SLRs). Reading habit has been diminishing among people in the recent times and also there is lot of effort required to obtain current knowledge through reading, critically evaluating and synthesizing literature [49]. Therefore, SLRs can serve as useful tools for updating oneself with the current evidence from their domain [49]. In addition, they can also be used for identifying lack or insufficiency of evidence in any specific area [49]. To obtain proper conclusions and gain knowledge in the particular area, various evidences need to undergo comparison and contrasting [48]. Hence, tertiary studies are performed on SLRs so as

to compare the evidences and provide a conclusion by analysing the extracted evidence.

3.2.1 Search Process

The exact search process mentioned by Kitchenham et al. in their study [1] has been replicated with few small changes. 3 digital libraries, one broad indexing system and SCOPUS indexing system have been considered in this study. The three digital libraries and the broad indexing system were IEEE, ACM, SpringerLink and Web of Science. The collection of studies from the digital libraries IEEE, ACM and SpringerLink was performed by Suhrullekha and indexing systems SCOPUS and Web of Science were taken up by Shravani. The digital library that haven't been used was Citeseer, as it did not have open access. The search process was performed during the months of March till May in the year 2017.

The exact search strings that were used in the tertiary study [1] were used. Those are listed as follows:

S1. "Software engineering" AND "review of studies"
S2. "Software engineering" AND "structured review"
S3. "Software engineering" AND "systematic review"
S4. "Software engineering" AND "literature review"
S5. "Software engineering" AND "literature analysis"
S6. "Software engineering" AND "in-depth survey"
S7. "Software engineering" AND "literature survey"
S8. "Software engineering" AND "meta-analysis"
S9. "Software engineering" AND "past-studies"
S10. "Software engineering" AND "subject matter expert"
S11. "Software engineering" AND "analysis of research"
S12. "Software engineering" AND "empirical body of knowledge"
S13. "Evidence-based software-engineering" OR "evidence-based software engineering"
S14. "Software engineering" AND "overview of existing research"
S15. "Software engineering" AND "body of published research"

The special search mentioned in the study [1] for SCOPUS was not followed, instead the 15 strings were used to collect the studies. The range of years considered were 7 complete years of 2010 to 2016, as the tertiary study [1] by Kitchenham et al. considered the studies from 1st January 2004 to 30th June 2008, and an updated study [50] has been done for the time period of 1st July 2008 till 31st December 2009.

3.2.2 STUDY SELECTION

The initial search, as mentioned earlier was performed by the authors of this thesis and the results of the initial search from the databases are given in Table 1.

Table 1: Initial search results with strings

STRING ID	IEEE		SCOPUS		ACM		Springer		Web of Science	
	Total	**Selected**	**Total**	**Selected**	**Total**	**Selected**	**Total**	**Selected**	**Total**	**Selected**
S1	1026	116	5	02	1	0	1	0	671	09
S2	0	0	2	0	0	0	1	0	209	03
S3	15	11	281	05	71	20	26	5	313	13
S4	10	09	623	18	123	20	47	0	467	05
S5	0	0	11	03	2	0	1	0	470	01

S6	0	0	0	0	0	0	0	0	16	0
S7	02	01	56	0	7	0	4	0	176	03
S8	48	04	45	0	11	0	18	0	27	01
S9	0	0	26	0	7	0	2	0	247	01
S10	0	0	21	0	7	0	3	0	28	0
S11	05	02	4	0	1	0	0	0	2077	04
S12	78	29	2	0	0	0	1	0	17	0
S13	06	06	87	2	0	0	0	0	83	03
S14	121	45	1	0	32	0	0	0	46	02
S15	117	38	0	0	0	0	0	0	17	01
TOTAL	**1428**	**261**	**1164**	**30**	**262**	**40**	**161**	**5**	**4864**	**46**

The initial selection was performed by considering the title and abstract by making sure that the studies belong to the domain of Software engineering. Zotero Standalone application was used as it provided facility to save the studies directly from digital libraries. It also facilitated the ease to sync results between both of the authors systems. As Zotero has been used, the authors also tried best to avoid repeated results since their first search. As part of human error, the search for IEEE database was performed by including the studies from 2009. So, 106 of those studies were excluded immediately after realizing it. The initial selection from IEEE database also included primary studies, but the auhtors later realized that all the primary studies were covered by the SLRs, hence 59 of those primary studies were excluded initially as well. Initial selection lead to collection of 217 studies which is shown in Table 2.

Table 2: Total Initial selection results

Database	**IEEE**	**Scopus**	**ACM**	**Springer**	**Web of Science**	**Total**
Search results	1428	1164	262	161	4864	**7879**
Initial selection	96	30	40	5	46	**217**

The further screening or the 2nd round selection of the results was done considering the Steps mentioned by Kitchenham et al. [1]. A quick preview of each study was performed to make sure that it was a full paper and not an extended abstract or Power point presentation. Some papers that had abstract in English but the rest of the paper in other language were excluded. The papers with the topics related to Computer Science or IS were excluded too. The other exclusion criteria considered were not SLRs, unclear strategy, duplicates and not for practitioners (or exclusively for researchers). The count of excluded studies at each criterion is clearly represented in Figure 4.

Therefore, after the inclusion and exclusion criteria obtained from Kitchenham et al. study [1] have been implemented, 67 studies were finally selected. The count of finally selected studies from each database is given in Table 3.

Table 3: Count of finally selected studies

DATABASE	**1st Screening**	**2nd Screening**
IEEE	96	30
SCOPUS	30	07
ACM	40	15
SPRINGER	05	03
WEB OF SCIENCE	46	12
TOTAL	**217**	**67**

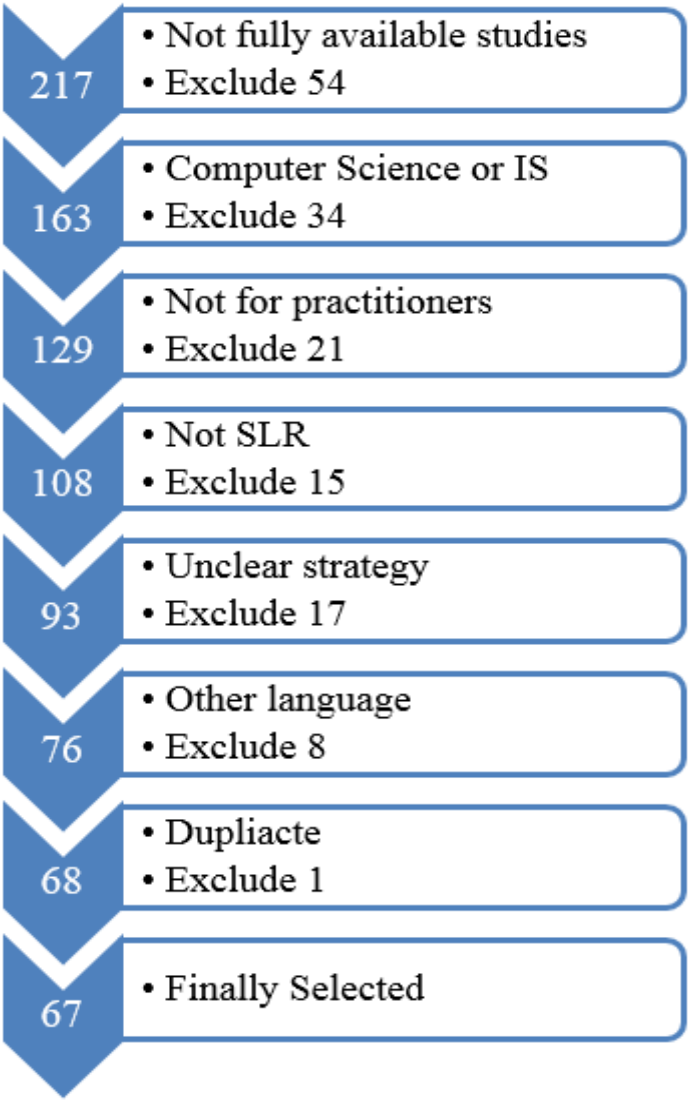

Figure 4: Inclusion and Exclusion criteria

3.2.3 DATA EXTRACTION PROCESS

The extraction was also done following the procedure given by Kitchenham et al. in their study [1]. The quality assessment, as done in the study, wasn't performed as the main aim was to gather the available existing evidence. The data from the collected SLRs has been retrieved by categorizing according to the following criteria:

- Database
- Year of publication

The data was extracted based on

- The paper type (Conference paper, Workshop, Journal article or Section of a book)
- Number of primary studied reviewed
- If evidence is given
- Topic addressed

3.2.4 DATA EXTRACTION RESULTS

As mentioned before, for each SLR of the 67 SLRs, the extracted data consisted

- If the evidence is given by the study
- The number of primary studies that have been reviewed in the SLR
- The main topic addressed or focused by the study

The data extraction results are shown in Appendix-A and the graph showing the Primary studies addressed by each SLR is in Appendix-B.

3.3 INTERVIEWS DESCRIPTION

Interviews can be used to directly capture the opinions and perceptions of practitioners. Even though there are other research methods like Case study, Experiment and Survey, we choose Interview study as our research method. Interviews give a wide opportunity and chance for a practitioner to express their wide range of opinions which lead us to choose it. The results of the experiments may be incorrect in real environment as they create artificial situations [51]. The participants in the experiment are also influenced by the environment and it's results may not be generalized to larger population [51]. Case studies are time intensive and also it's results cannot be generalized in a conventional way [52]. Even though survey results are based on people's perceptions and idea's which is the main requirement in our study, it is not possible to approach practitioner's directly. It is possible by conducting interviews with which we can capture the required data [53]. There are three types of interviews: structured, semi-structured and unstructured [54]. Structured interviews are easy, quick and use clear specific questions. Semi-structured interviews have prior planned questionnaire format but the flow changes spontaneously according to the involvement of the interviewee. Unstructured interviews, on the hand, are unorganized with no prior planned questionnaire. Semi-structured interviews have been followed in this study.

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The sample size of population chosen for conducting interviews was an optimum number of 15 but 18 interviewees were finally found and selected. The sample population for this study has been selected using one of the non-probability sampling method, as it consists the properties of convenience and economical [55] that best suits this study. Non-probability method has various names such as deliberate sampling, purposive sampling and judgment sampling [55]. It is done by purposefully selecting the sample population based on few demographic factors such as organization type, experience (in years) and country. Here, the sample population has been chosen based on the preliminary qualification of being a software practitioner. Henceforth, the population was aimed to cover different types of organisations such as global, local and start-ups. The graphs of population covered, number of years of experience, and the country or the region of the practitioners is represented in the results section.

3.3.1 QUESTIONNAIRE SPECIFICATION

A pattern of semi-structured interviews with open-ended questionnaire was followed for conducting the interviews. Interviews depended on many factors such as the nature of the interviewee, their main role in industry, experience and environment of the interaction. Hence, many spontaneous questions were asked apart from the prior prepared questionnaire. Nevertheless, all the questions asked were eventually to answer the main research questions, the barriers and facilitators, hence, they were grouped under four categories, which are: a) decision-making, b) research results, c) barriers and facilitators and d) awareness. Each category is explained further as follows:

a) Decision-making: The questions under this category focused on obtaining the experience of practitioners in decision-making, the sources considered by the practitioners for making decision and also the practical challenges faced in decision-making.

b) Research results: This section included questions focusing on the research results from the academic side. These questions were asked based on the answers received from the decision-making section. The questions under this section were on the practitioners' opinion on usage of research results to solve problems faced in decision-making.

c) Barriers and facilitators: Here, the direct questions are asked which are about barriers that hinder research results from being implemented and facilitators that promote research results in industry. The questions on the effect of change due to research implementation on customers and staff behaviour were also asked. Other questions were asked on opinions on academic and industry collaboration and on time taken for research to be fully implemented.

d) Awareness: The questions in this section were mainly asked to know the overall status and perception on academic research evidence among the software practitioners. So, the questions were asked on how much are the practitioners aware of the existing evidence, how many of them would be ready to accept it and what can be done to increase the awareness and usage.

The questions have been updated after every interview. Each interview lead to refinement of the questionnaire.

3.4 DATA COLLECTION METHOD

Interviews help an interviewer to pursue an idea or opinion into more detail. In semi-structured type of interviews, although predetermined questions are prepared by an interviewer, the interviews take place in a conversational manner. It helps in gathering the necessary information that is important for an interviewer. This motivated us to choose semi-structured interviews.

Many software practitioners are contacted through e-mails requesting for interview participation followed by scheduling interviews. The reason for interview and research purpose is clearly stated in the e-mails sent. Interviews are conducted with experts from different organizations. The interviews are scheduled based on the convenient time of the interviewee. All the interviews were conducted for a time span of 30 minutes to 1 hour. The conducted interviews were audio recorded with the consent of

the interviewees. In some cases, field notes were maintained by the interviewees for better understanding of the results. The conducted interviews include face-to-face, skype or telephonic interviews depending on the availability of the interviewee. The questions asked are tabulated in Appendix-C.

3.5 DATA ANALYSIS METHOD

3.5.1 TERTIARY STUDY

The data analysis method that the authors followed for Tertiary study is Narrative synthesis. It is defined as the narrative summary of the findings of the study [56]. Narrative synthesis can be applied to reviews of both qualitative and quantitative research [57]. Though there are many data analysis methods, the main motivation behind choosing this method that it helps in the synthesis of findings from multiple studies and explains the findings of the synthesis [56]. Hence, this analysis method has been used to analyse the results obtained from Tertiary study.

3.5.2 INTERVIEW STUDY

The data analysis method followed for Interviews is Thematic analysis [58]. As the authors are analysing the data from different interviews, Thematic analysis helps in analysing the data effectively [59]. This was performed using four phases like: "familiarizing with the data collected", "generating codes", "mapping of themes" and "producing report [58]."

Familiarizing with the data collected- The data is collected from all the transcribed interviews. The authors have collected and documented all these interview recordings as a part of data extraction process. Every transcribed interview is revised thoroughly to get a clear idea of the data collected.

Generating codes- As a part of this phase, the words used in interviews were obtained and were afterwards grouped to be coded. This assures that the information collected is according to the conducted interviews and helps in analysis.

Mapping of themes- After the generation of codes, the codes are categorized and themes according to the collected data. The authors also make sure if the collected data is sufficient for our research.

Producing reports- All the themes are finally generated into a report. In this phase, the authors also check if the anticipated results are obtained.

3.6 SUMMARY

As explained in this section, the research methods used for answering the formulated research questions were tertiary study and interviews. Therefore, 67 SLRs were collected and reviewed as a part of tertiary study. Semi-structured interviews have been performed among 18 software practitioners by scheduling carefully within the given time of this study. The interviews have been recorded with the consent of the

interviewees and later deleted after transcribing their answers and opinions. This has been done as to ensure that no opinion is missed from the practitioners. The transcribed interviews have later been analysed and summarized for extracting the required output relevant to this study. The results obtained from each method and their analysis comparing each characteristic, opinion and factor are given in the further sections.

4 RESULTS AND ANALYSIS

This section depicts the results obtained from the tertiary study and conducted interviews. The sub-section 4.1 presents the results obtained from the tertiary study and answers the research question 1. The sub-section 4.2 presents the results obtained from the conducted interviews and answers the research questions 2 and 3.

4.1 TERTIARY STUDY RESULTS AND ANALYSIS

As mentioned in the proposal, a tertiary study is conducted which is an update of the study by Kitchenham et al. [1]. The required literature for the tertiary study was extracted from IEEE, Scopus, Springer, Web of Science and ACM databases.

The articles in the previous study conducted by Kitchenham et al. [1] were included from the publication years 2004 to 2009. As an update of the study conducted by Kitchenham et al. [1], in this study the selected articles were included from the publication years 2010 to 2016. The year wise categorization of the SLR's from the previous study [1] and present study is graphically represented in Figure 5.

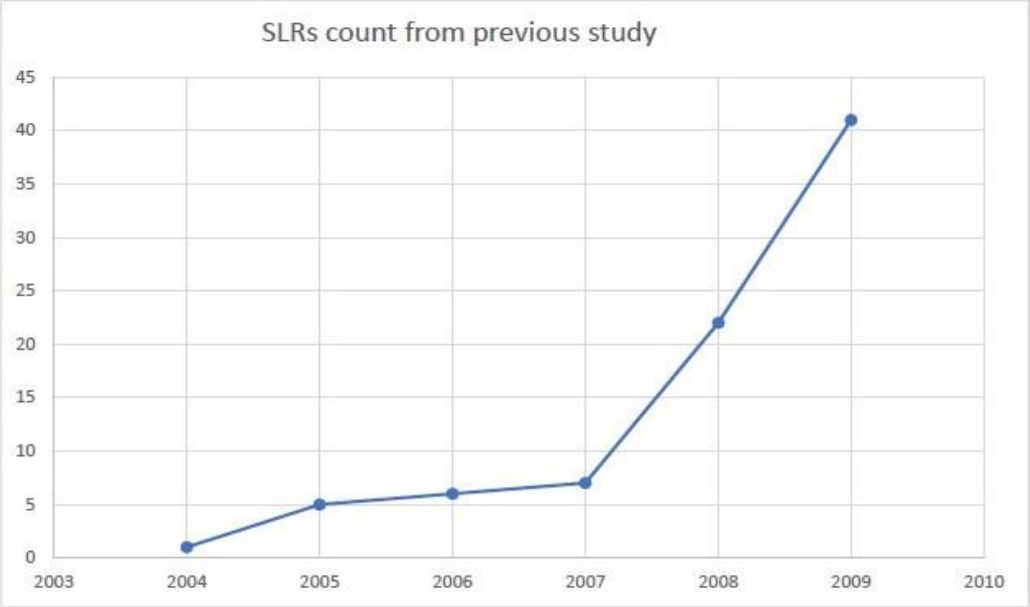

Figure 5: Graph of year-wise categorization of the SLR's from Kitchenham et al. study [1]

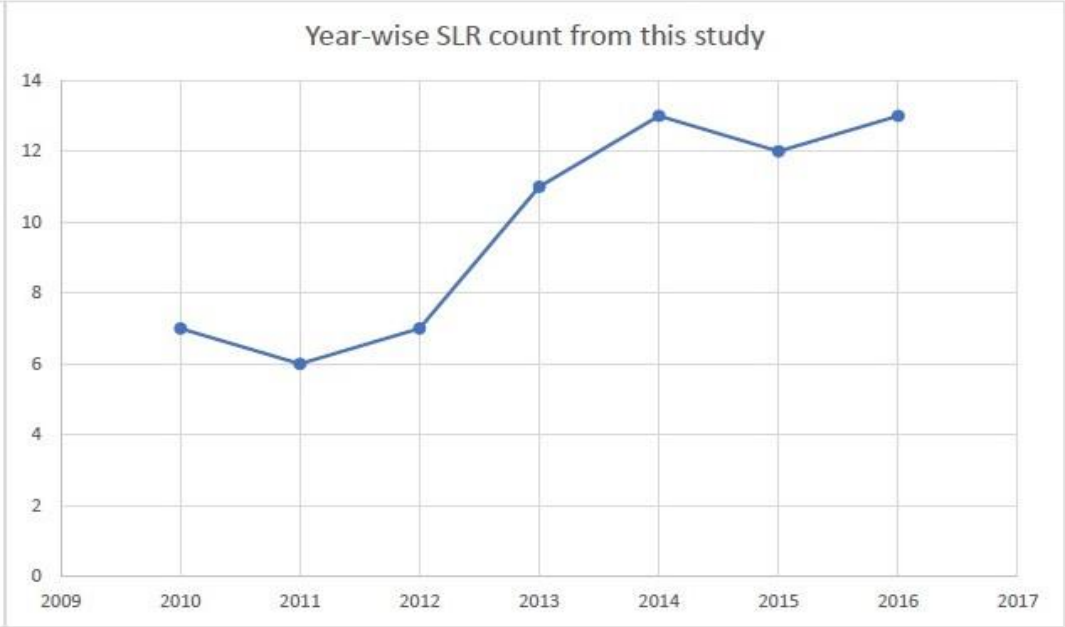

Figure 6: Graph of year-wise categorization of the SLRs from this study

The graphs from Figure 5 and Figure 6 show that there has been an increase in number of SLRs in software engineering with the passage of time.

The selection of articles from each of the databases and their comparison is graphically represented in Figure 7.

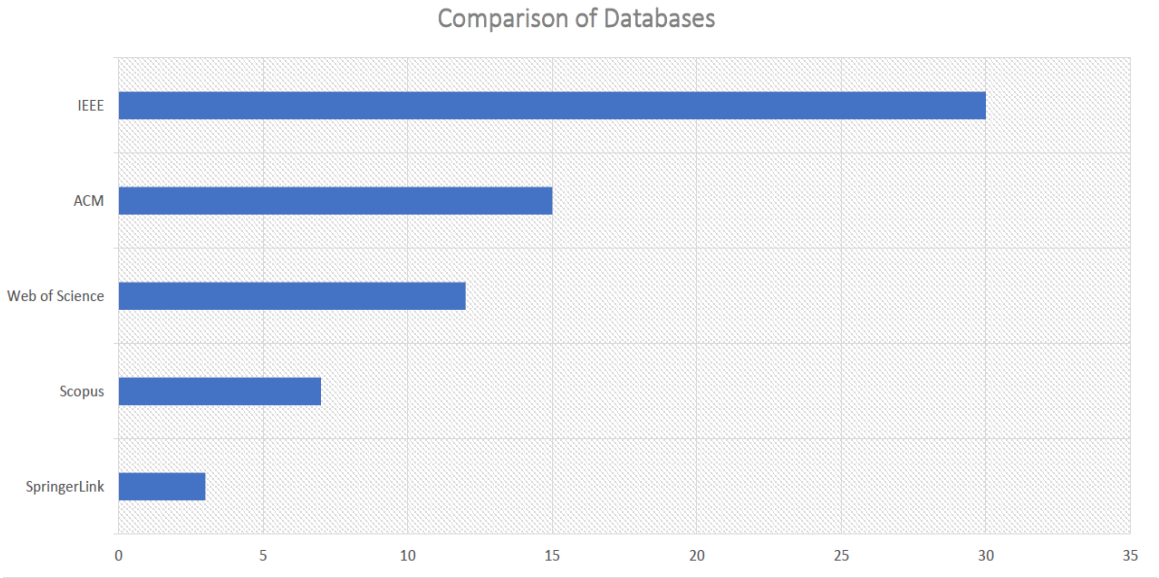

Figure 7: Comparison of data bases

The graph of number of primary studies according to the study type is presented in Appendix-B.

The count under each type of study is graphically represented in Figure 8.

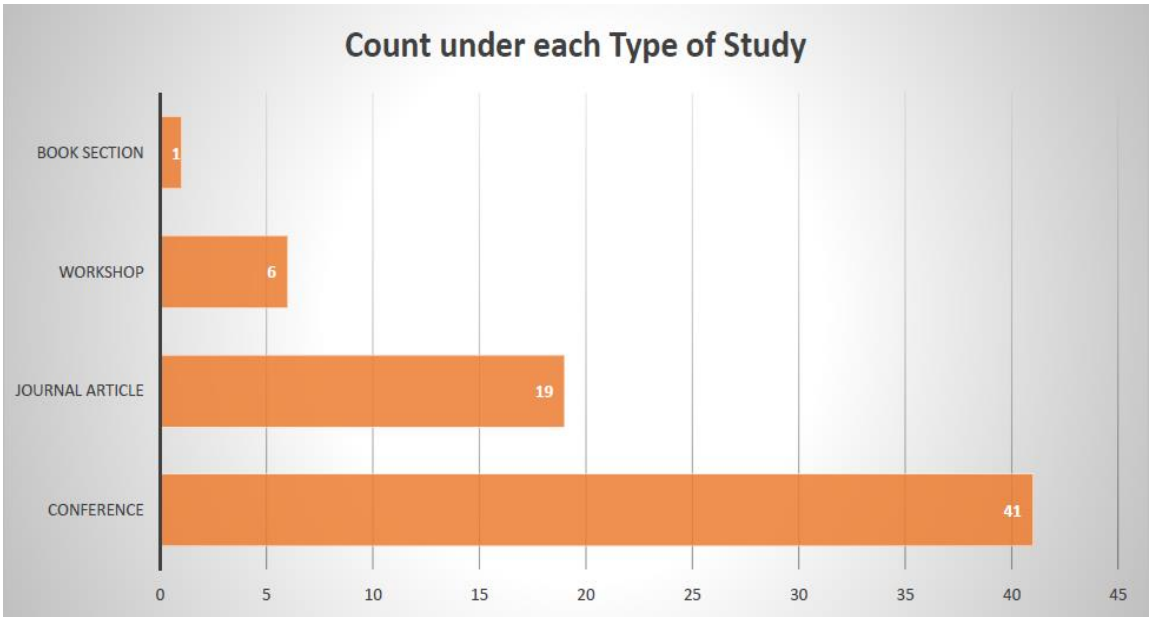

Figure 8: Count under each Type of Study

Out of the 67 selected articles, the studies under each topic are represented graphically in Figure 9.

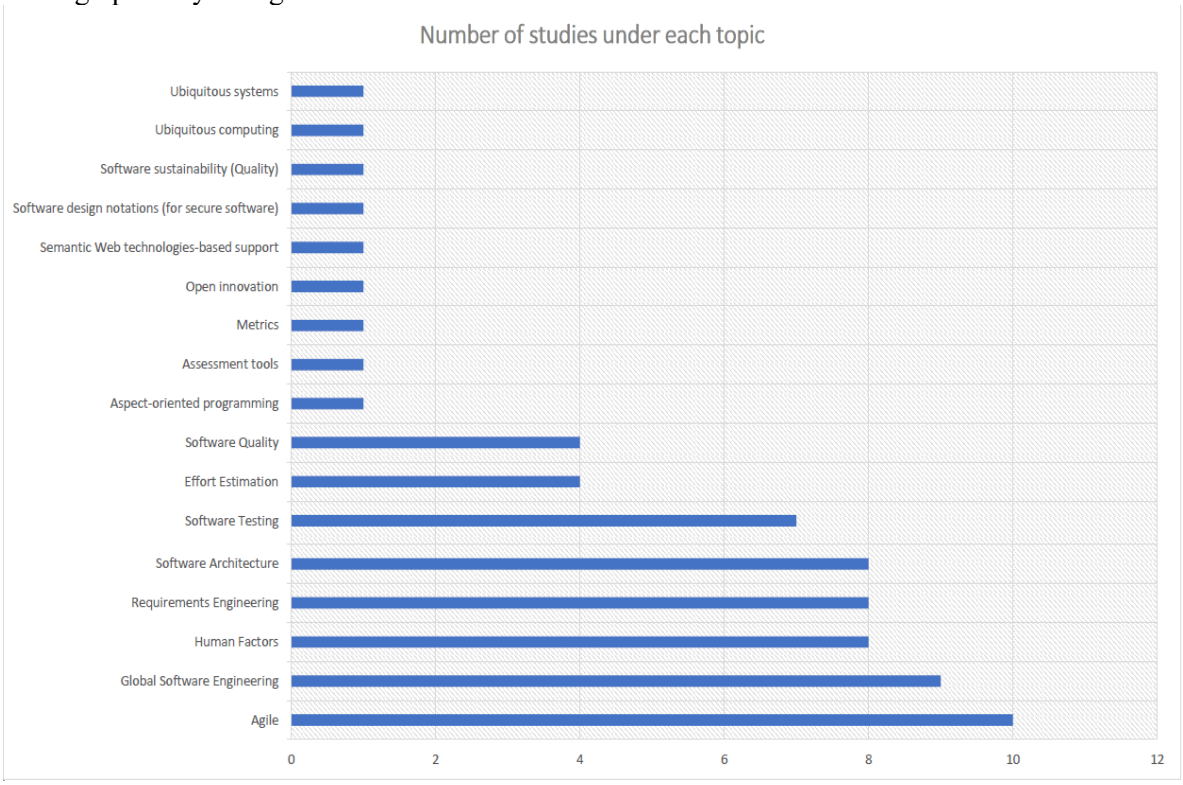

Figure 9: Number of studies under each topic

The studies under each type, year-wise from Kitchenham et al. [1] and the present study are represented in the graphs below in the Figure 10.

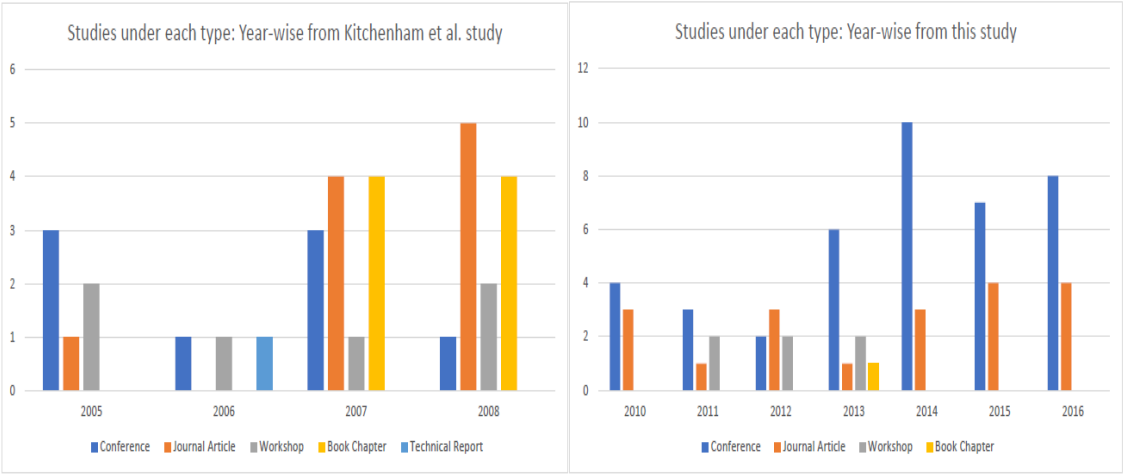

Figure 10: Year-wise studies under each type from Kitchenham et al. [1] and present study

From the graphs of Figure 10, it can be seen that SLRs from conferences have increased in the recent times especially from 2013. There has been a rise that was seen in journal articles in the previous study whereas there almost constant number obtained from the present study.

The graph for each topic showing their variation over the years under each topic has been prepared and is represented in Figure 11.

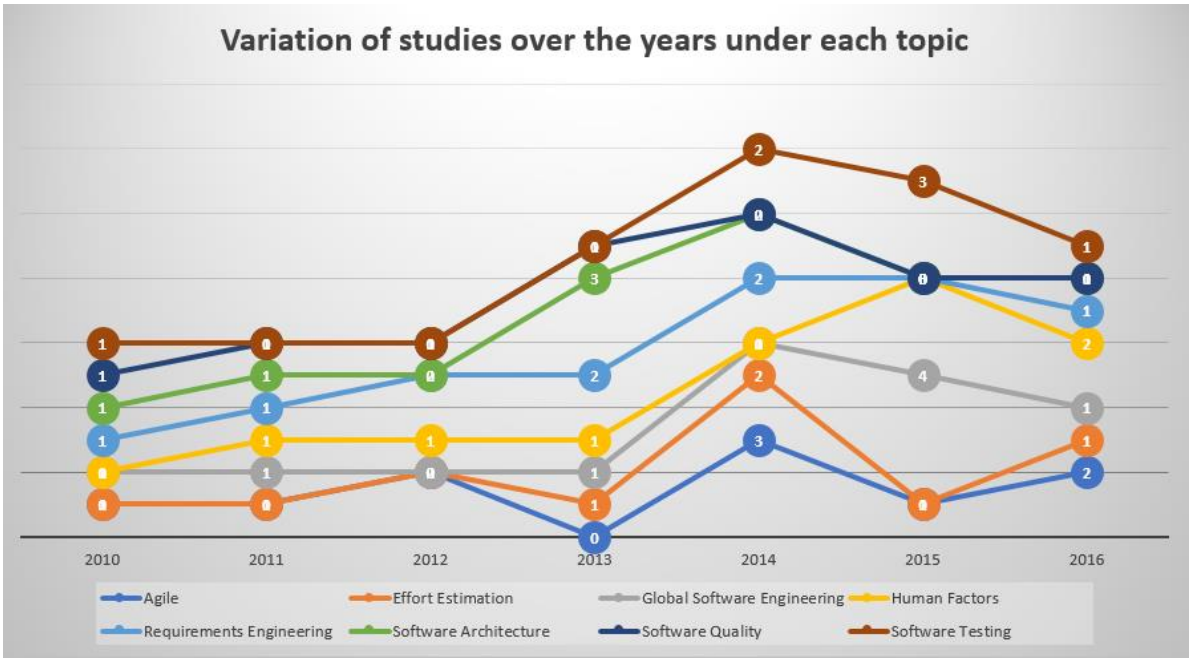

Figure 11: Variation of Studies over the years under each topic

The graph representing the studies belonging to others category with their topic and the year they belong to is represented in the Figure 12.

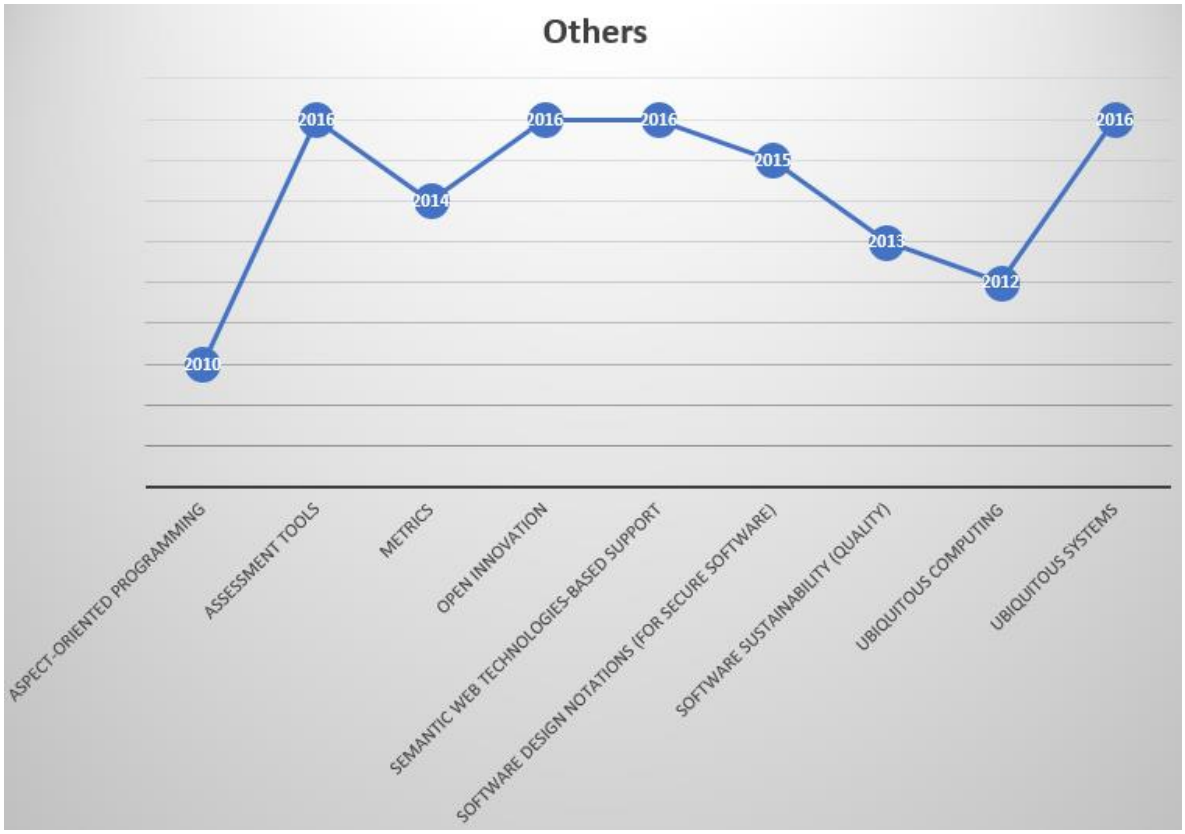

Figure 12: Studies belonging to other categories

The evidence obtained from each of the 67 selected articles according to each topic are tabulated under Appendix-D.

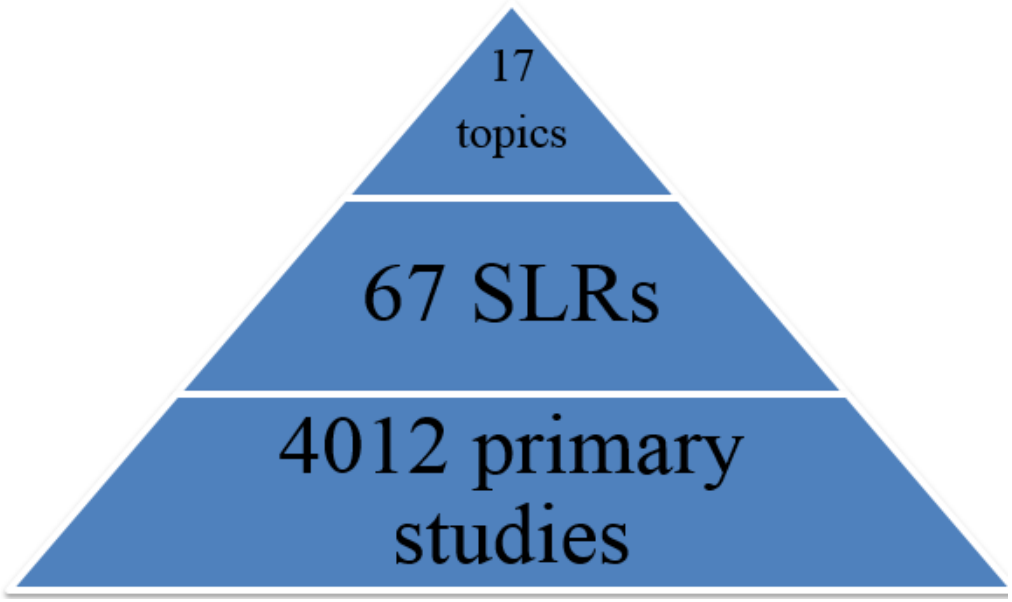

Figure 13: Pyramid showing the output of Tertiary study

By analysing results of the tertiary study, the pyramid from Figure 13 was obtained which was used in the later sections to obtain connection to the conducted interviews through knowledge pipeline. The knowledge pipeline concept was adapted from the healthcare domain, but here it was implemented for representing the knowledge flow in software engineering domain.

4.2 INTERVIEWS RESULTS AND ANALYSIS

4.2.1 DEMOGRAPHIC RESULTS FROM THE INTERVIEW STUDY

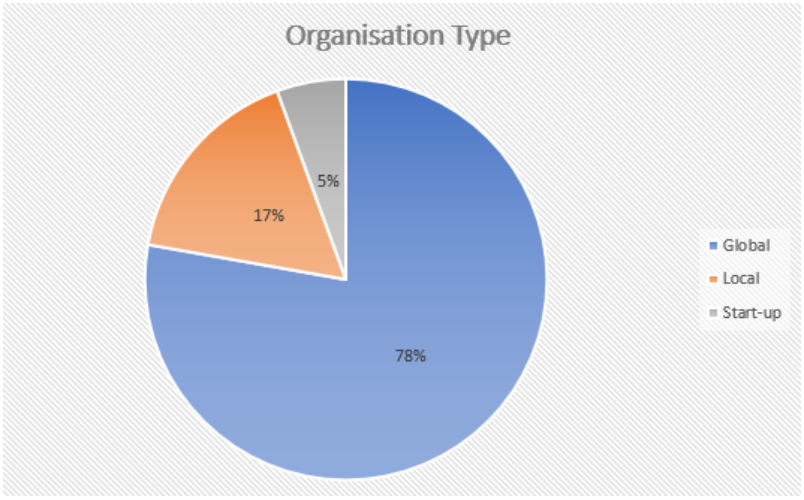

Figure 14: Pie Chart showing the percentage of population that is distributed among different types of organisations

The population covered from the organisation types is represented in Figure 14.

Figure 15: Graph showing the experience (in years) of the practitioners

It was also made sure that the sample population selected based on number of years of experience to cover at regular intervals within the range of 1 to 35. It is represented in the graph in Figure 15.

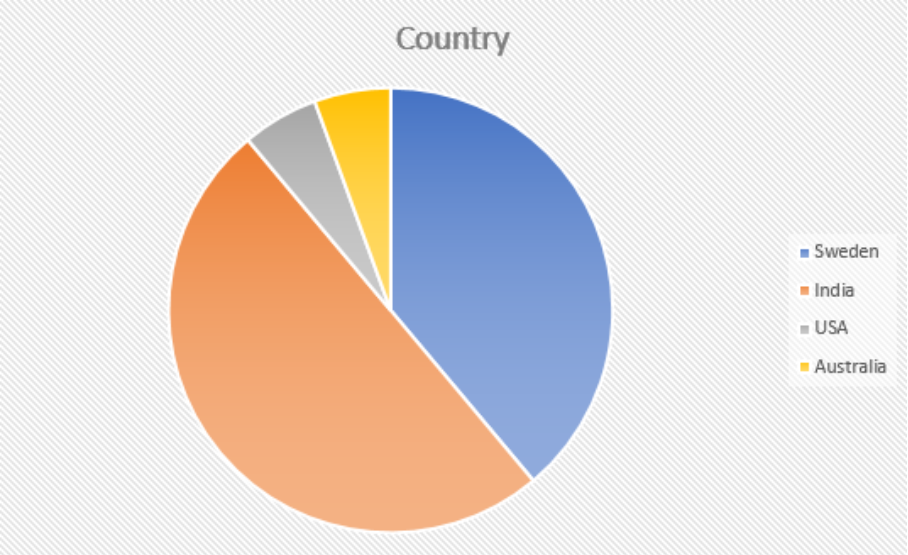

Figure 16: Pie chart showing the proportion of practitioners from different countries

Opinions according to the country or the region of the practitioner were also planned to be captured. Hence, practitioners finally selected belonged to four countries covering different continents such as Sweden from Europe, India from Asia, USA, and Australia.

Figure 16 represents the pie chart showing the proportion of practitioners from different selected countries. It can be observed that there have been more practitioners from Sweden and India, hence, the opinions captured in this study were more inclined to those regions.

The interviewees were analysed based on their background in practice and research, which is tabulated in Table 4. It has been assured to the interviewees that their identity would be kept anonymous throughout this report. Therefore, the coding method of thematic analysis has been used to give each interviewee a new ID to refer throughout the report. The required details of each interviewee are tabulated in Appendix-E. A graph has been obtained from those details which is represented in the Figure 17.

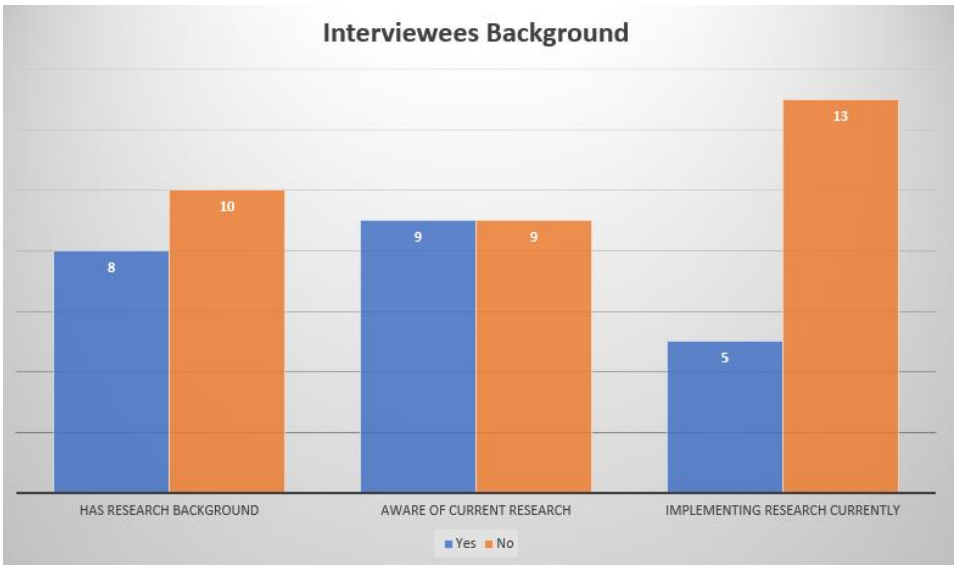

Figure 17: Graph showing Interviewees background in research

The levels of practitioners with research background and practitioners that are aware of current research can be seen from Figure 17. The practitioners that were aware of current research were not all of the ones that had research background. They varied from the research background and current awareness as it depends on personal interest and other such factors. The level of practitioners that claimed to be implementing research is quite low though nearly half of the interviewed practitioners had research background and half were aware of the current research. The lack of practical implementation could be clearly seen from this graph. The reasons behind this occurrence is what this the further results of the interviews deal with in the form of barriers and facilitators.

Table 4: Interviewee Details

Interviewee	Experience (in years)	Current Role	Previously involved in Managerial Roles
Interviewee-1	24	Professional Licentiate of engineering	Yes
Interviewee-2	30	Technical Specialist	Yes
Interviewee-3	28	Professional Licentiate of engineering	Yes
Interviewee-4	24	System Architect	Yes
Interviewee-5	9	Senior Lead Software Consultant	No
Interviewee-6	13	Software Manager	Yes
Interviewee-7	7	Technical consultant	No
Interviewee-8	21	Software Architect	Yes
Interviewee-9	14	Software Developer	No
Interviewee-10	20	Owner of Start-up	Yes
Interviewee-11	9	Software Developer in Telecom company	No
Interviewee-12	33	Freelance consultant in Process management	Yes
Interviewee-13	15	Software Developer	No
Interviewee-14	8	Software Developer	Yes
Interviewee-15	2	Software Developer	No
Interviewee-16	14	Project Manager	Yes
Interviewee-17	30	Application Analyst	Yes
Interviewee-18	10	Project Manager	Yes

Figure 18: Pie chart showing the percentage of practitioners with managerial experience

From Figure 18, it can be seen, that among the practitioners, selected for the interviews, 67% were involved in managerial roles in their career, whereas 33% were not, but results considered were of both the categories in this study so as to obtain conclusions by comparing based on the managerial experience.

The answers obtained under each question are summarized and tabularized in Appendix-F.

Although there are many other procedures for analysing the results which are obtained during interviews, Thematic analysis has been selected. Thematic analysis help in analysing the data effectively [59]. It involves the following phases: "familiarizing with the data collected", "generating codes", "mapping of themes" and "producing report" [59]. Thematic analysis has been used to analyse the conducted interviews.

There have been various results obtained from the conducted interviews covering many factors of the practitioners. The required aspects have been carefully recorded, compared and analysed.

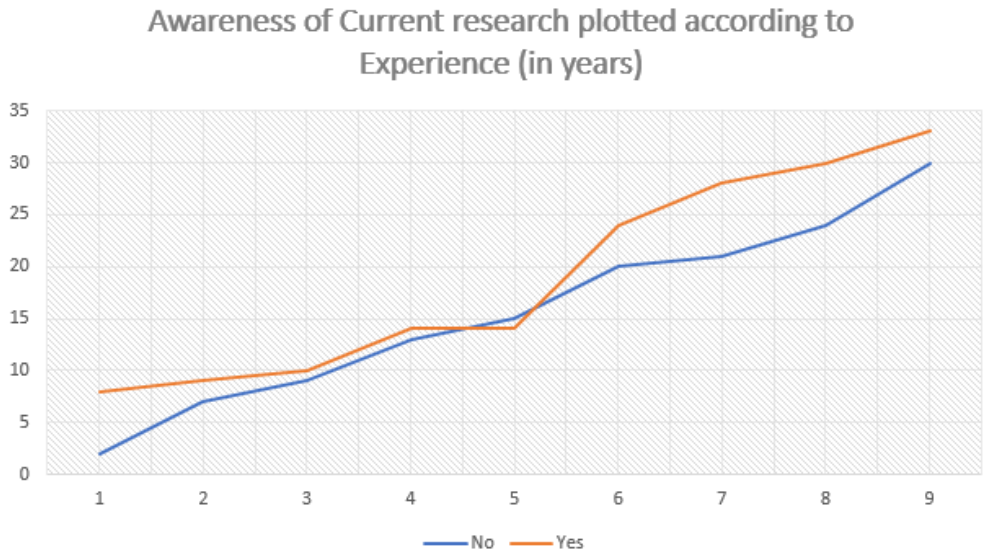

Figure 19: Graph showing the practitioners' awareness on current research according to their experience (in years)

The graph in Figure 19 is a Line chart that is showing the awareness among the practitioners according to their experience (in years). The orange line represents those that are aware of current research and blue line represents those that are not aware of current research. It can be clearly observed from this graph that years of experience has got no dependency on the experience of a practitioner, as not all practitioners with highest experience are aware of current research, neither are all practitioners with lowest experience unaware of current research.

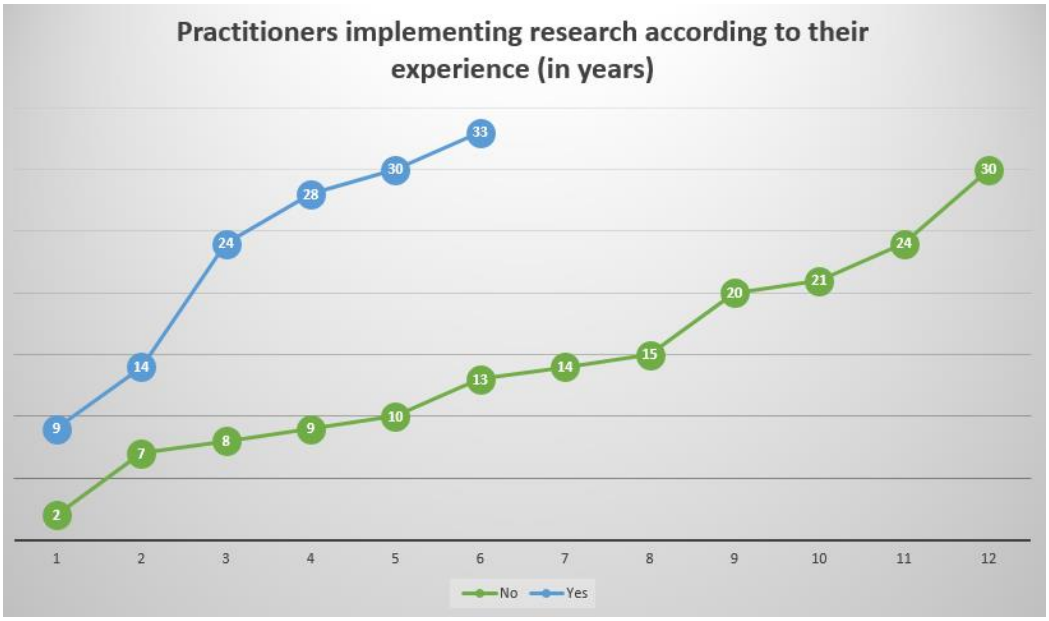

Figure 20: Graph of practitioners implementing research results in practice against their experience

The graphs from Figure 20 shows the variation of practitioners according their experience based on whether they implement or do not implement research results in practice respectively. The number of practitioners from the interviewees of this study implementing research results are comparatively less than those not implementing research results. Regardless of the count, the experience does not seem to have much

relation in this case as well. From the Figure, it can be seen, that there have not been any practitioners with less than about 10 years of experience that are implementing research results in practice. Whereas, there exist practitioners with experience of around 20 to 30 years and are not involved in any research result implementation in practice.

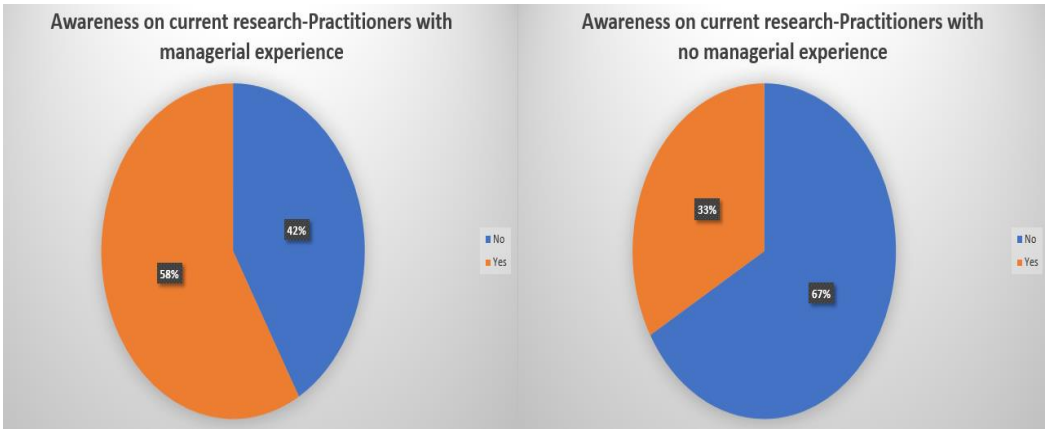

Figure 21: Pie chart showing awareness of current research among practitioners with managerial experience (left) and without managerial experience (right)

From Figure 21, it can be observed that the proportion of practitioners aware of current research is more under the ones with managerial experience, whereas the proportion of practitioners unaware of current research is more under the ones with no managerial experience. Therefore, it can be said that the practitioners involved at management level face requirement of existing research results and are hence involved in one way or the other in accessing them.

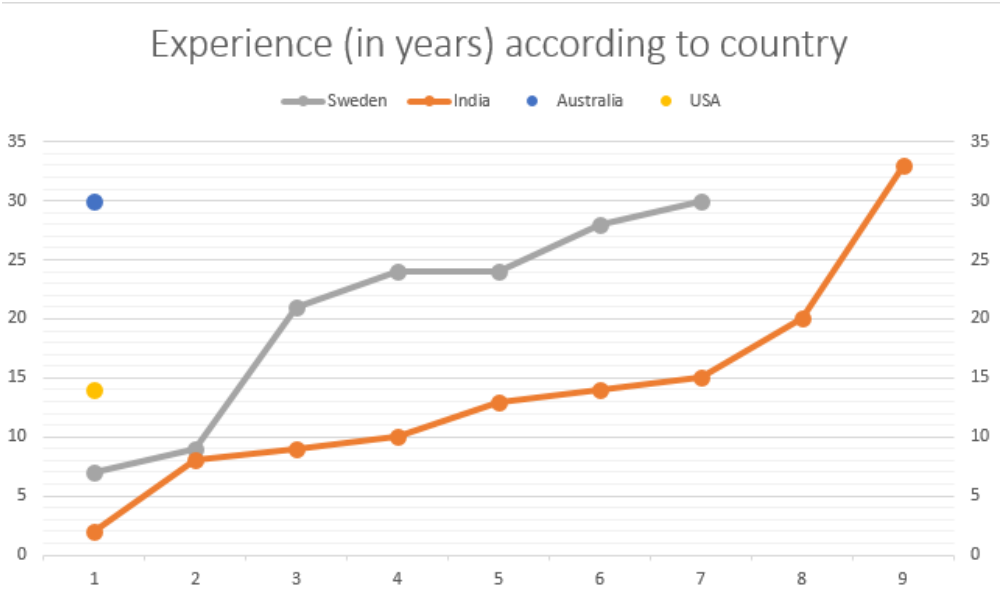

Figure 22: Graph showing the experience (in years) of practitioners according to the country

The graph in Figure 22 shows the experience (in years) of the selected practitioners over different countries. As it can be seen, the practitioner selected from Australia was of high experience whereas practitioner selected from USA was of minimum experience. Therefore, any conclusions made regarding Australia and USA

were carefully analysed and made. The practitioners from Sweden and India involved different levels of experience which helped in making many conclusions on the opinions and awareness of research results.

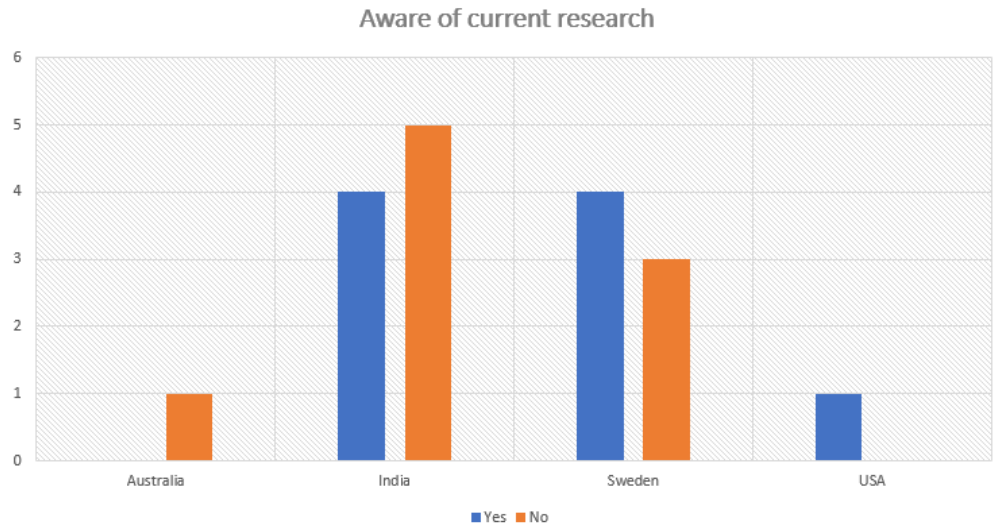

Figure 23: The graph showing awareness of current research according to each country

From Figure 23, though Australia and USA show a result, considering the factors such as experience, the practitioner from Australia was of higher experience than the practitioner from USA. Hence, those two regions were not considered for this analysis. Nevertheless, it can been seen from the levels in India and Sweden that the practitioners that are aware of research and those that are unaware of current research are almost same which means that the region has no large effect on awareness, it mostly depends upon each individual and experience.

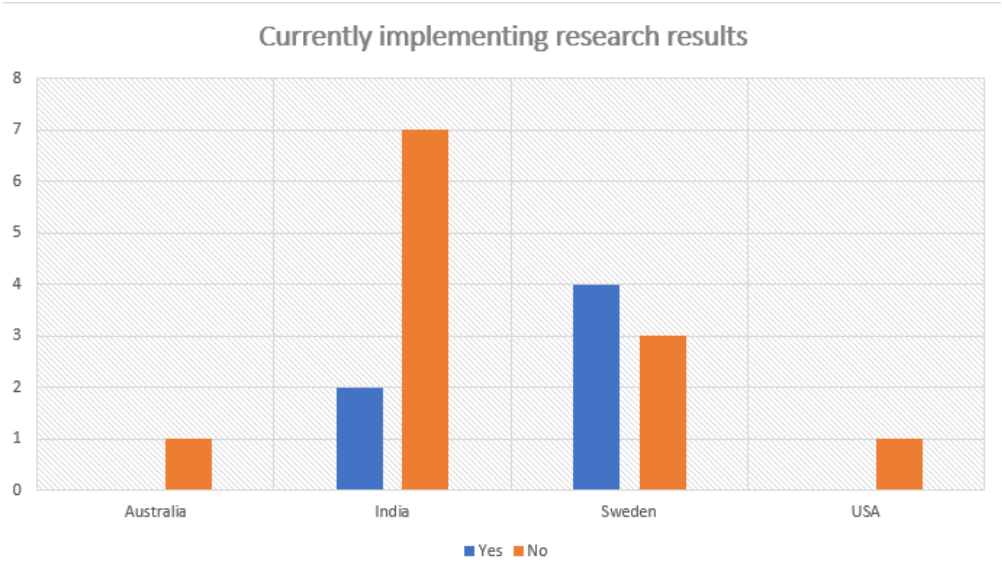

Figure 24: The graph showing practitioners implementing research results according to each country

From Figure 24, it can be seen from India and Sweden that the practitioners involved in currently implementing research results are comparatively more in Sweden and India has more number of practitioners that are not involved in any implementation of research results. This means that the region has a role playing in implementation of research results in practice. This has been brought up by one of the interviewees from India, that has visited their office in France, saying that the style of work or research in France differs vastly from that of India.

4.2.2 THEMATIC ANALYSIS

The Interview results are analysed using Thematic Analysis [59]. This was performed using four phases like: “familiarizing with the data collected”, “generating codes”, “identifying or searching for themes” and “producing report [59].”

Familiarizing with the data collected: After every interview was conducted, it was transcribed. The audio clips were heard multiple times by the authors to check the accuracy of the transcribed data. The transcribed files were reviewed at least once to check the correctness of the sentences and to get more familiar with the interview answers.

Generating Codes: Coding of the transcribed interviews was performed using a tool called NVivo to obtain the frequently used words and their details from the interviews. The word cloud images from the tool are represented in Appendix-I. The words which were out of slang, pauses or other such unimportant words were rejected. The words that were significant to this study, with the details of number of practitioners that mentioned them, are listed in Appendix-G, and coding is performed on them by marking them with unique colours. The transcribed interviews were referred continuously to group the words under categories. The words of similar category were marked with one specific colour, and they have been assigned codes. The codes formed from the words are represented in flowcharts of Appendix-H. Every interviewee is also coded as Interviewee 1, Interviewee 2, Interviewee 3, and so on to maintain the anonymity. The answers obtained from coded interviews are inserted in the steps of the knowledge pipeline according to relevance.

Mapping of themes: A set of codes were gathered under unique theme based on the relevance according to their context from the interviews. The figures showing the thematic networks formed are represented in Appendix-H. The themes formed are listed in Table 5.1.

Producing the report: And report is produced as an outcome in this study by listing out the human factors, organisational activities, factors that effect decision-making, sources referred for decision-making, barriers and facilitators. The obtained codes with their themes are represented in Table 5.

Table 5: Table of obtained codes and themes

S.no.	Theme	Codes	Refined codes
1	Decision-making factors	Time	Time
		Organisation goal	Organisation goal
		Trust	Trust
		Need	Need
		Money	Budget
2	Human factors	People	People
		Behavioural patterns	Behavioural patterns
3	Sources	Organisation internal sources	Organisation internal sources
		Based on experience	Experience
		Internet sources	Internet
		Influencing factors	Influencing factors
		Current scenario	Current scenario
		Personal opinion	Personal opinion
4	Barriers	Format	Format
		Internal factors of organisation	Internal factors of organisation
		External factors	External factors
		Hierarchy	Hierarchy
		Customer	Customer
		Need is not seen	Need is not seen
		Internal research	Internal research
		Results in academic perspective	Results in academic perspective
		Unforeseen factors	Unforeseen factors
		Cultural issues	Cultural issues
		Uncertainty	Uncertainty
		Fear	Fear
		Manage new recruitments	Manage new recruitments
		Time	Time
		Research result issues	Research result issues
		Additional requirements	Additional requirements
		Money	
5	Facilitators	Collaboration	Collaboration
		Early publishing	Early publishing
		Awareness	Awareness
		Valid results	
		Open access	Open access
		Understandable Format	Understandable Format
		Modification of research results	
		Innovative representation	Innovative representation
		Practitioners initiative	Motivation for practitioners
		Motivation	
6	Organisational activities	Organisation	Organisation
		Activities	Activities
		Actions	Actions

4.2.3 BARRIERS THAT ARE HINDERING THE UTILIZATION OF THE EVIDENCE IN PRACTICE

The barriers that are hindering the utilization of the evidence in practice obtained from the interviewees are explained in Table 6.

Table 6: Barriers and their description

Barrier ID	Barriers	Description
B1	Format	The research studies from academia are written in academic format with lot of textual content. The vocabulary from academic field also differs from organisational vocabulary in certain cases. Adding to this, there are thousands of papers in the digital libraries. This makes it difficult for a practitioner to find the required outcome.
B2	Internal factors of organisation	Internal factors such as transparency maintained, licence issues, agreement issues, competition, guidelines followed, system, structure, traditions, methodology, structure and such effect freedom of practitioners to implement research in practice.
B3	External factors	External factors such as environment of organisation involving government rules, scenario with other organisations, expected consequences, etc. might hinder research from being implemented in practice.
B4	Hierarchy	The existence of hierarchy in the organisation may sometimes hinder practitioners to bring in research into their work. This is mainly because any major initiation in an organisation completely depends upon the top management. The minor changes too are mostly under the control of practitioners at managerial and leadership levels. Therefore, many times it solely depends upon the practitioners in those positions to introduce research results.
B5	Customer	Customer are the main focus of any organisation and they play a major role for any change. Sometimes, the change brought in by the research results may not immediately satisfy the customer needs, and may result in delay of production or a needless change in the outputs dissatisfying the customers. As customers cannot see the long-time benefits sometimes, they can be a barrier for research implementation in practice.
B6	Need is not seen	The practitioners in the organisation may not recognise the need for research in their work as they are satisfied with what they doing.
B7	Internal research	Some of the organisations have research carried out internally with their recruited researchers

		and hence do not prefer to look for research from academia.
B8	Results in academic perspective	Some practitioners feel that the research done and the results obtained are in academic perspective and do not show the direct benefits to practitioners. This barrier is not similar to the difficulty in understanding the research studies format.
B9	Unforeseen factors	There might be emergency situations in the organisation which may require regular well-known practices to be implemented by the staff.
B10	Cultural issues	The organisational culture and the regional culture play a significant role in implementation of research in practice. Some cultures can easily accept change whereas some take time and effort.
B11	Uncertainty	Practitioners feel uncertain about the research results giving the estimated output. The research results given seem vague for them. They cannot trust the results from academic research. There might be disagreements due to misinterpretation of the data. Also, the uncertainty is involved in knowing the where exactly would the research results be applicable in practice.
B12	Fear	There might be many fears for bringing in a change. The practitioners might not be comfortable with changes, slowing down the progress. The new methods might have been tested among a smaller sample and might be risky to implement directly with thousands.
B13	Manage new recruitments	Lot of additional time would be required to train newly recruited staff in an organisation. They take time to learn regular practices, culture and environment of the organisation, apart from the work. Introducing research results would add up the burden on them.
B14	Time	Time can be one of the major barrier that hinder utilization of research results in industry. This is because organisations run with projects according to planned period, which leave practitioners to face deadlines and time constraints resulting with least chance to think about academic research.
B15	Research result issues	The research results may be hard to find, the specific required research result may not be available, the research result may not be customized for implementation and other such issues related with research results hinder research implementation in practice.
B16	Additional requirements	Implementation of research results may require additional requirements such as change of existing methods, re-planning, re-organizing, money etc., which can be one of the reasons to hinder smooth adaption of research results in

		practice.
B17	Human factors	The behavioural patterns of the practitioners matter a lot to bring research results into practice.

When asked about the different barriers that are hindering the utilization of evidence in practice, each of the interviewee listed out the barriers presented in figure 3 according to their perceptions.

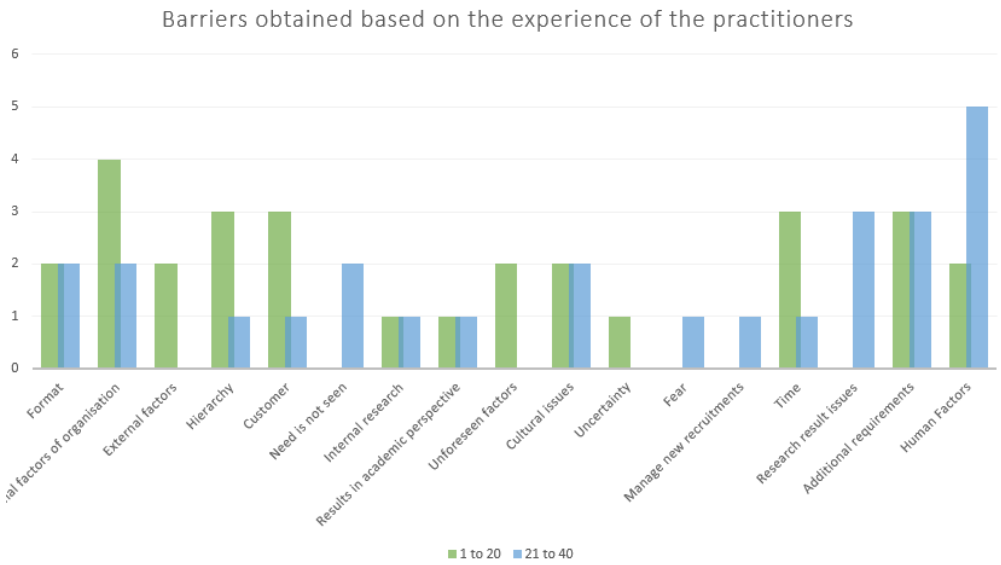

Figure 25: The obtained barriers plotted according to experience (in years)

Figure 25 shows which barriers have been mentioned according to the experience (in years) of the practitioners. The green and blue lines represent experience (in years) of 1 to 20 and 21 to 40 respectively. The remaining graphs follow in the same style in this sub-section. It can be observed from the graph that practitioners above 20 years of experience have mentioned about all the barriers except "external factors" and "uncertainty". This is because most of the interviewed practitioners with higher experience did not have problem with trusting the research results but were affected by other barriers. The barriers such as "need is not seen", "fear", "manage new recruitments" and "research result issues" could not be raised by the practitioners with lower experience. It could be observed during the interviews that these practitioners were satisfied with their work and organisational routine and did not give thoughts to improvise and bring change on higher extent. It can be observed that "internal factors of organisation" and "human factors" are the ones mentioned by many practitioners regardless of the experience.

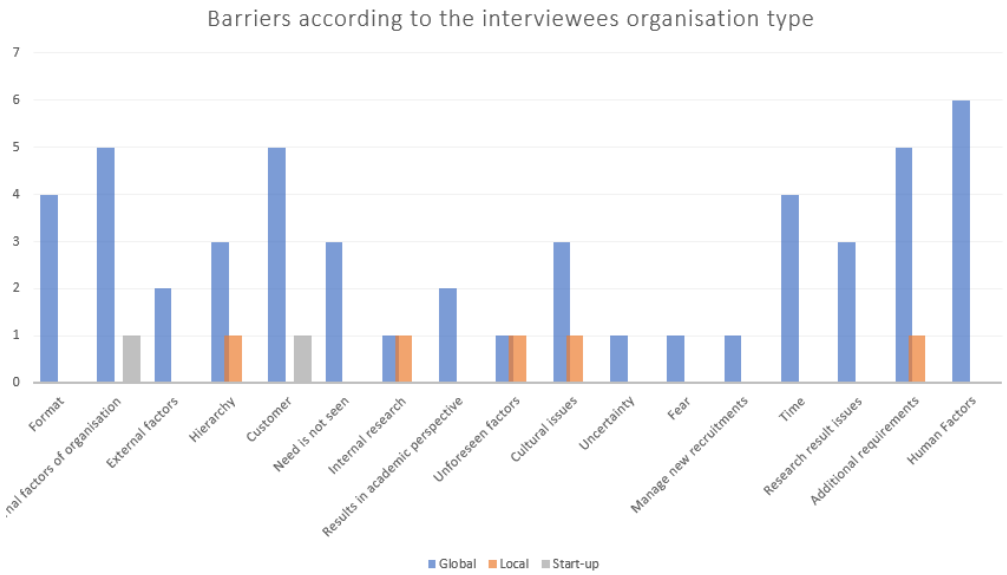

Figure 26: The obtained barriers plotted according to the Type of Organisation

Figure 26 represents the graph plotted to view the barriers mentioned by each type of organisation. Most of the practitioners selected in this study belonged to global organisations, hence, all barriers are mentioned by them. Nevertheless, it can be seen that local and start-up organisations face "internal factors of organisation", "hierarchy", "customer" issues, "unforeseen factors", "cultural issues" and additional requirements" barriers.

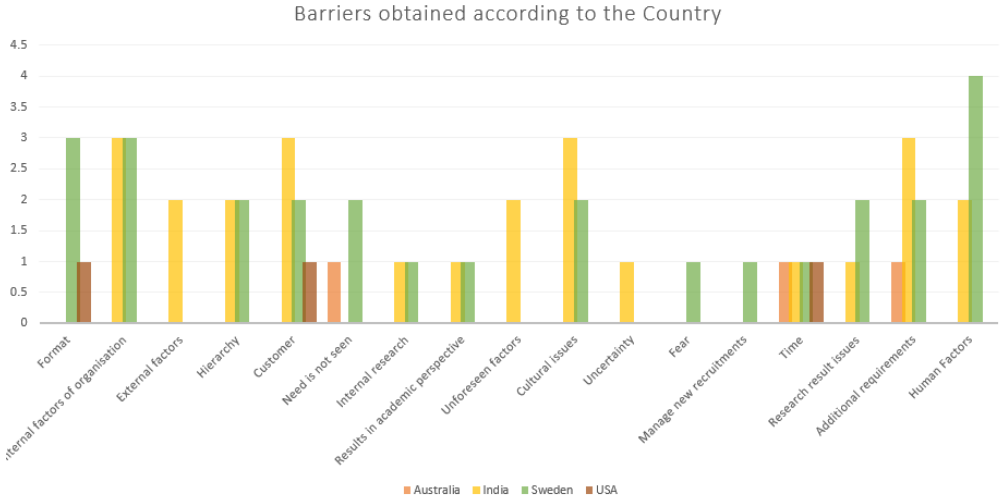

Figure 27: The obtained barriers plotted according to the country

Figure 27 shows graph plotted according to the country to know if barriers change with change in region. "Customer" and "Time" issues is the barrier mentioned by practitioners from all regions, as time constraints, deadlines, customers and such factors are same in organisations all over the world.

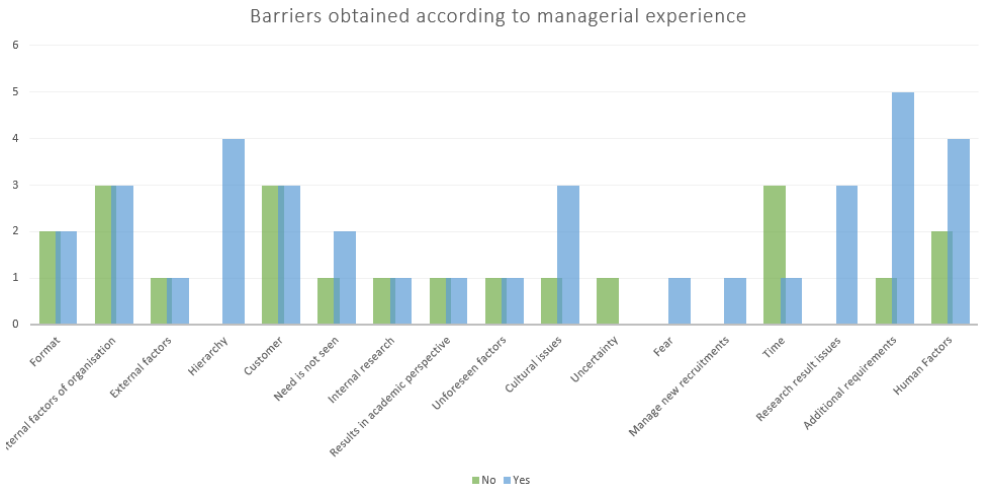

Figure 28: The obtained barriers plotted according to the managerial experience

From Figure 28, it can be seen, that barriers such as "internal factors of organisation", "customer" issues, "additional requirements" and "human factors" are mentioned by most of the practitioners with or without managerial experience. "Hierarchy", "additional requirements" and "human factors" are mentioned by most of the practitioners with managerial experience.

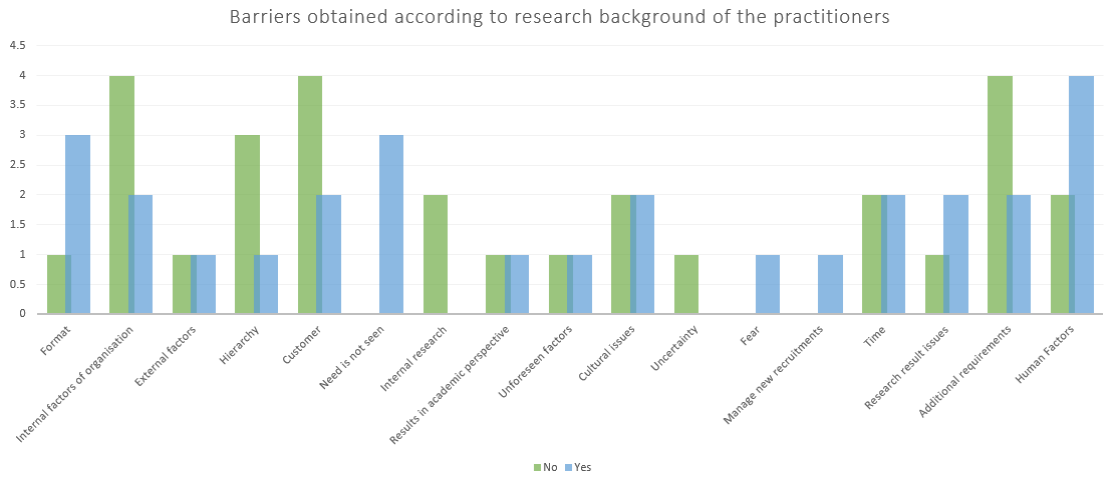

Figure 29: The obtained barriers plotted according to research background

From Figure 29, it can be observed that "internal factors of organisation", "customer" issues, "additional requirements" and "human factors" have been faced at high level by the practitioners with and without research background. It can be seen, that practitioners with no research background exclusively mentioned "internal research" and "uncertainty". This is because the practitioners with no research background cannot perceive the importance of the evidence existing in academic research, which shows significance of awareness among practitioners to reduce research to practice gap.

4.2.4 FACILITATORS WHICH HELP IN IMPLEMENTING RESEARCH EVIDENCE IN PRACTICE

The facilitators which help in implementing evidence in practice stated by interviewees are explained in Table 7.

Table 7: Facilitators and their description

Facilitator ID	Facilitators	Description
F1	Collaboration	Good interaction among the academic researchers and practitioners. So that the researchers are available for the practitioners to explain and clarify misinterpretations of the research outcomes.
F2	Early publishing	In academia, there is a time gap existing from completion of a successful research till it is published. Immediate availability of the new research outcomes for the practitioners would reduce research to practice gap as organisations are currently seeking for the immediate outcomes. Also, the trends in technology have also been changing in a rapid fashion which would cause time gap to be a major drawback.
F3	Awareness	From the results of interviews conducted in this study, it was found that majority of the practitioners are unaware of the existing research evidence. Measures such as surveys, mails or collaborative conferences would increase awareness among practitioners and also to ensure the validity of the research outcomes.
F4	Open access	Most of the published research studies from digital libraries are not free. Open availability of these studies would give practitioners better chance to access them.
F5	Understandable Format	Improvisation of the academic research studies format targeting the understandability of the practitioners. Clear conveyance of the outcomes or the results pertaining to the practitioners through usage of special sections or highlights.
F6	Innovative representation	The research results of academia are mostly in text format, diagrams or images. Innovative representations involving videos, animations or other such forms would gain practitioners attention towards research outcomes.

F7	Motivation for practitioners	The practitioners should be motivated to realise the benefits of academic research results in practice. The practitioners should also be made aware of the requirement of research in their domain so as to stimulate initiation from them.

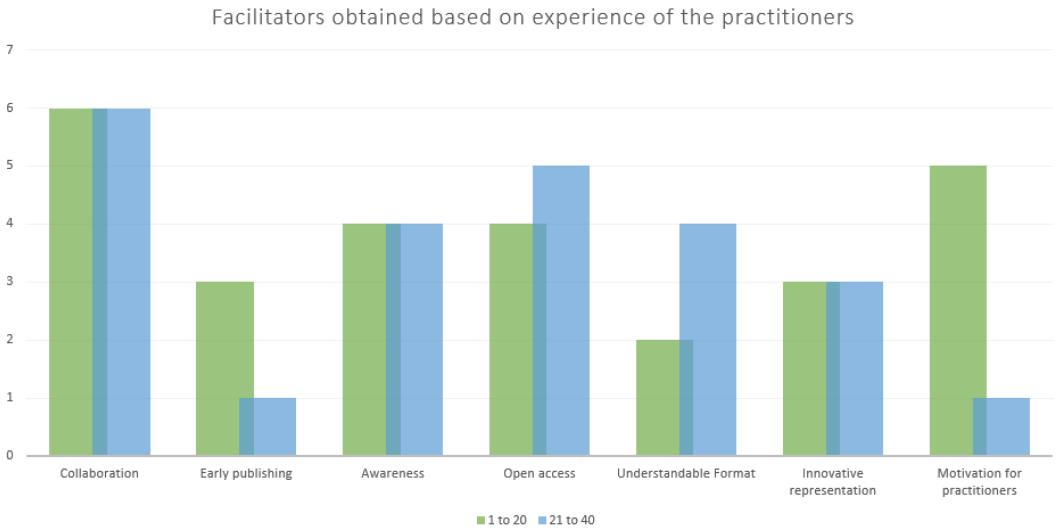

Figure 30: Obtained facilitators plotted according to the years of experience

Same as the graph of barriers Figure 30 shows which facilitators have been mentioned according to the experience (in years) of the practitioners. The green and blue lines represent experience (in years) of 1 to 20 and 21 to 40 respectively. Here, we can see that "collaboration" is mentioned by all the practitioners for facilitating research in practice. This means that the practitioners require guidance, interpretation and understanding of the research results to implement successfully and researchers need to know the exact industrial requirements for the research to be of highest relevance in practice. "Motivation for practitioners" was mentioned by most of the practitioners with lower experience which shows the requirement of motivation for all the freshers and younger practitioners to reduce research to practice gap.

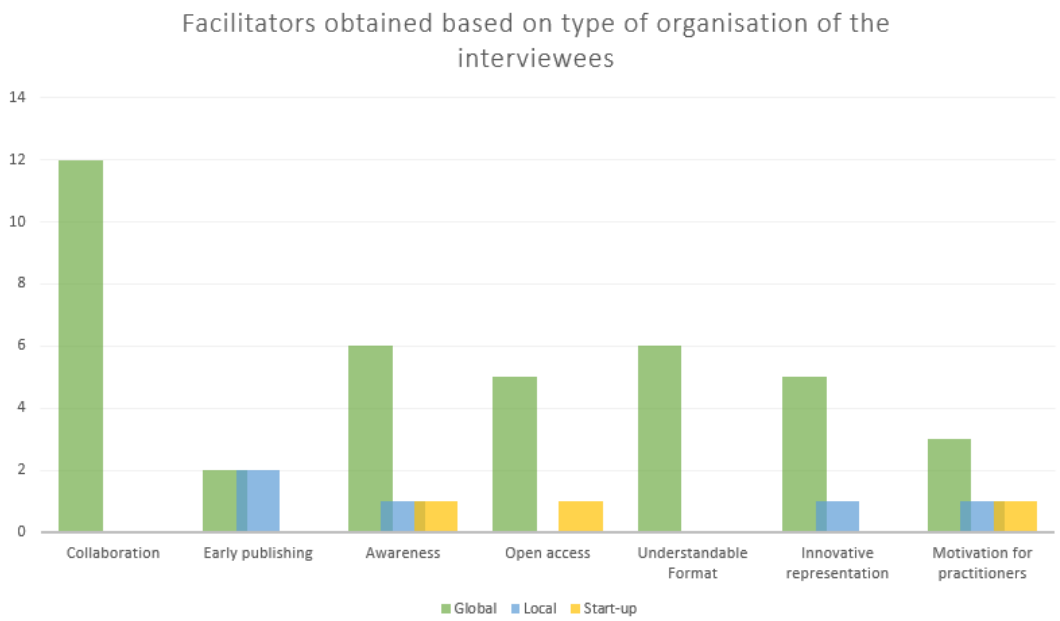

Figure 31: Obtained facilitators plotted according to the organisation type

From Figure 31, it can be seen that "collaboration" and "awareness" are the facilitators mentioned by most of the practitioners. It can be said that "collaboration" is highly sought for again, because interaction with people from research field would solve many trivial issues such as increase in trust. Collaboration can improve implementation of research evidence in practice as collaboration would involve exchange of knowledge among researchers and practitioners resolving many issues.

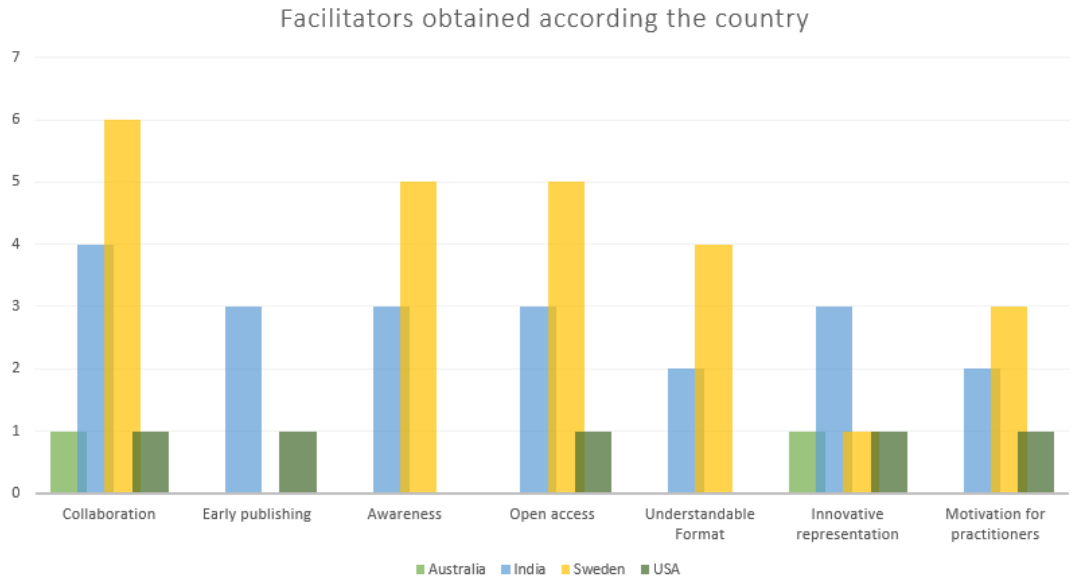

Figure 32: Obtained facilitators plotted according to country

Figure 32 shows that "collaboration" is look forward by practitioners from every country. The practitioner from Australia has also mentioned that there is heavy collaboration implemented presently in Australia among students and industry which has led to increase in success among industries. It was also mentioned by the interviewee that there are not many disadvantages involved in collaboration and the advantages surpass the disadvantages.

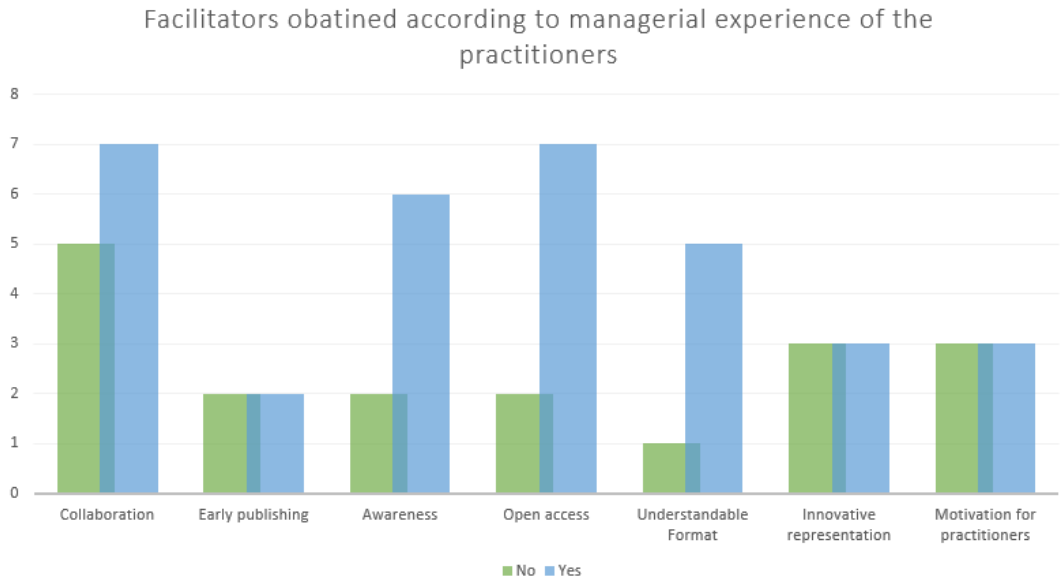

Figure 33: Obtained facilitators according to managerial experience

It can be seen from Figure 33 that all the facilitators have been mentioned by every practitioner regardless of managerial experience, but it can be observed that "collaboration", "awareness" and "open access" have been highly recommended by most of the practitioners of managerial background.

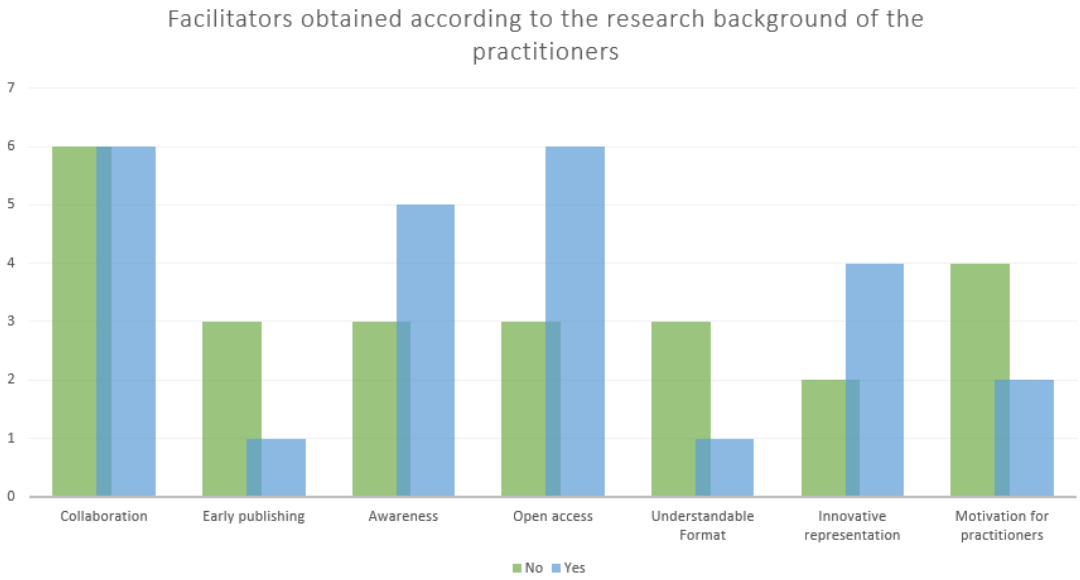

Figure 34: Obtained facilitators plotted according to research background

Figure 34 shows the plotting of facilitators according to research background and it can be seen, that all the facilitators are recommended by practitioners regardless of their research background.

4.2.5 THE STEPS OF KNOWLEDGE PIPELINE

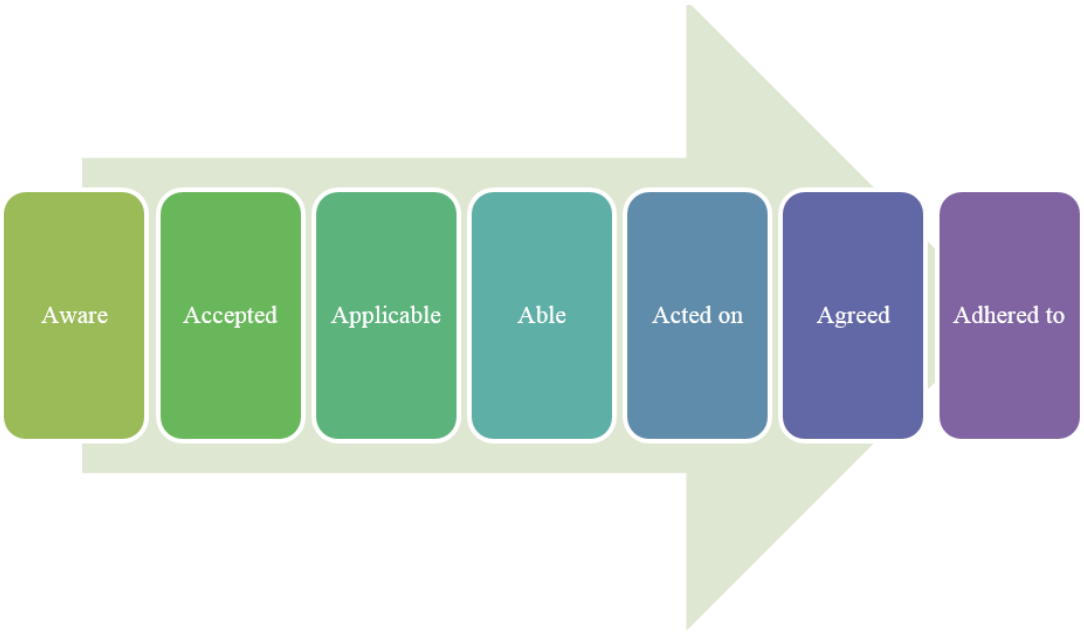

Figure 35: Knowledge pipeline steps

The knowledge pipeline steps show the levels that practitioners go through for successfully implementing research results in practice. The steps are represented in Figure 35 and description of each step is given in Table 8.

Table 8: The steps of Pipeline involved in Knowledge translation from Evidence to Practice process

Pipeline Steps	Description
Aware	The level that the practitioners are aware of the existing research.
Accepted	The level that practitioners are able to accept the research evidence.
Applicable	The practitioners can perceive the need of research and the domains to implement it.
Able	The practitioners are able to apply the research evidence.
Acted on	The research evidence is implemented in practice among practitioners.
Agreed	The practitioners have agreed and accepted the implemented research.
Adhered to	The practitioners are well used to implementation of research results.

4.2.6 BARRIERS CATEGORIZED UNDER THE STEPS OF KNOWLEDGE PIPELINE

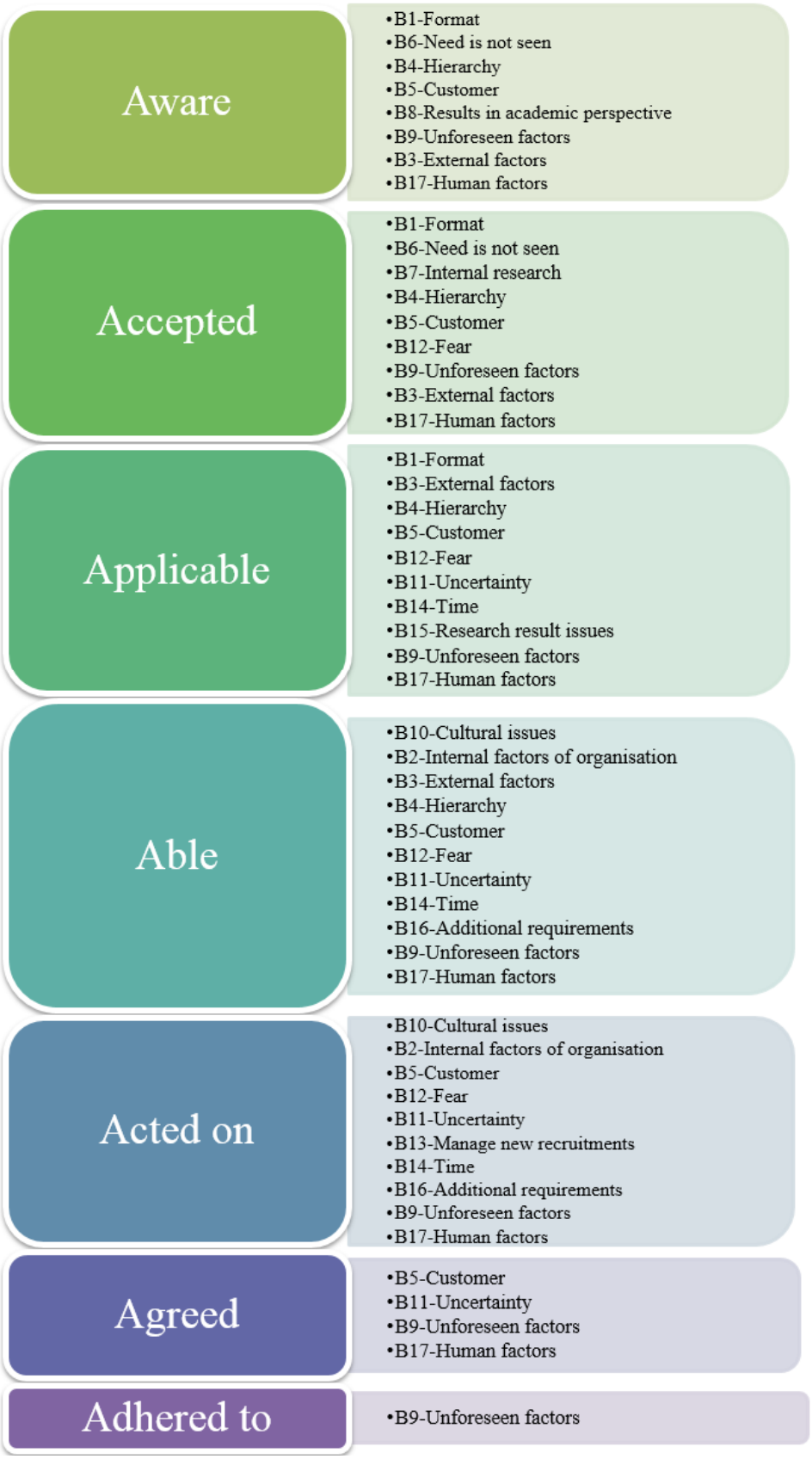

Figure 36: Barriers under steps of knowledge pipeline

The obtained barriers from the interview results have been categorized under steps of the knowledge pipeline and it is represented in Figure 36.

4.2.7 FACILITATORS CATEGORIZED UNDER THE STEPS OF KNOWLEDGE PIPELINE

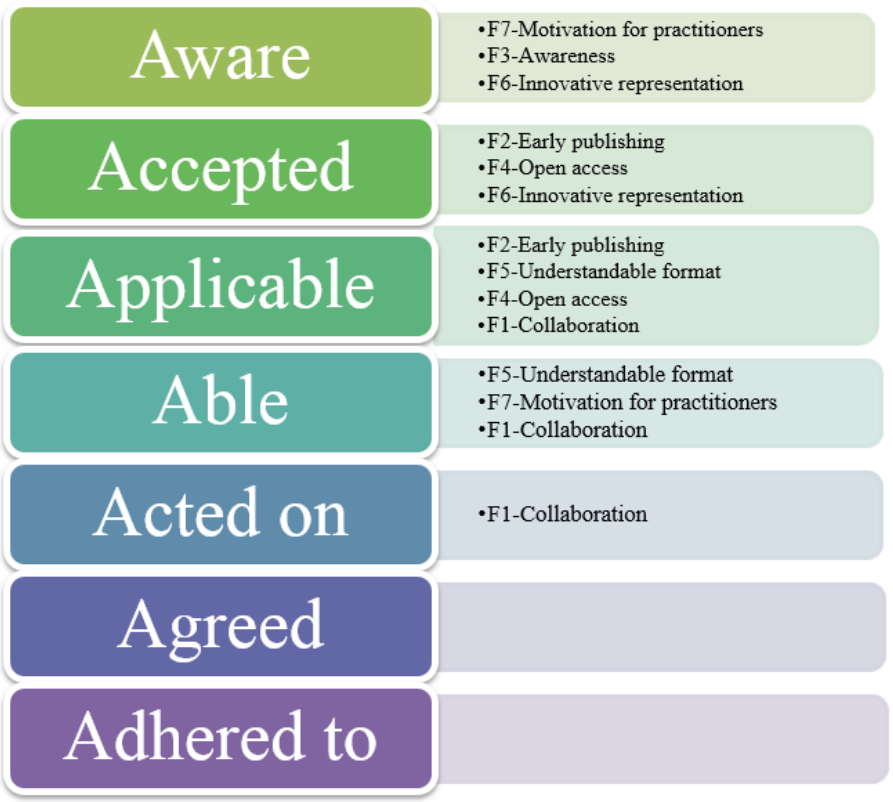

Figure 37: Facilitators under the steps of knowledge pipeline

5 ANALYSIS AND DISCUSSION

This section is divided into four sub-sections. Section 5.1 presents the analysis of the tertiary study. Section-5.2 consists of the analysis of the interview results. Section 5.3 deals with the discussion of all the research questions. Section 5.4 presents the Validity Threats.

5.1 TERTIARY STUDY ANALYSIS

Narrative synthesis is used to analyse the Tertiary study results later followed by a categorization process. The analysis is done to find out the existing evidence that can facilitate practitioners in decision-making.

5.1.1 PUBLICATION YEAR

In the previous study by Kitchenham et al. [1], the SLR's were from the time period of 2004 to 2008. In this study, the SLR's published from the years 2009 to 2016 were selected. The search strategy followed, resulted in 7879 articles out of the five data bases. Applying 1st step of inclusion criteria, SLR's, software engineering related papers, fully available English language papers were included. The papers which contained PPT's, just abstracts and duplicate papers were excluded. It resulted in 217 articles. Applying 2nd step of inclusion criteria, software engineering papers were included by analysing in depth and papers providing evidence. Computer science and IS (Information systems papers) were excluded. It resulted in 67 articles. By comparing the previous study by Kitchenham et al. [1] and present study, it is evident that the number of SLR's being published is increasing year to year[1] . The selected 67 articles are analyzed and presented under categories.

5.1.2 CATEGORIZATION

The 67 articles were analysed in depth and the existing evidence from each of the article was listed out and categorized them under various topics. The analysis is done to know the use of existing evidence in practice:

The analysis is done to know the use of existing evidence in practice:

- 14.92%(10 out of 67) related to Agile use existing evidence in practice.
- 13.43%(9 out of 67) related to Global software engineering use existing evidence in practice.
- 11.94%(8 out of 67) related to Software Architecture use existing evidence in practice.
- 11.94%(8 out of 67) related to Human factors use existing evidence in practice.
- 11.94%(8 out of 67) related to Requirements engineering use existing evidence in practice.

- 10.44%(7 out of 67) related to Software Testing use existing evidence in practice.
- 5.97%(4 out of 67) related to Effort estimation use existing evidence in practice.
- 5.97%(4 out of 67) related to Software Quality use existing evidence in practice.
- 13.43%(9 out of 67) others (related to Software sustainability, Metrics, Assessment tools, Software design notations (for secure software), Open Innovation (OI), Semantic Web technologies- based support, Aspect-oriented programming, Ubiquitous systems, Ubiquitous computing) use existing evidence in practice.

It clearly indicates that most of the existing evidence is applied in practice in Agile, Global software engineering, Human factors, Requirements engineering and Effort estimation, Software quality areas to an extent. Software sustainability, Metrics, Assessment tools, Software design notations (for secure software), Open Innovation (OI), Semantic Web technologies-based support, Aspect-oriented programming, Ubiquitous systems, Ubiquitous computing) use existing evidence in practice to a very less extent.

5.2 INTERVIEW ANALYSIS

Table 9: Related topics based on the type of the decision made by the interviewee

Role of the Interviewee	Related topics based on the type of decisions made
Professional Licentiate of engineering	Agile, Global software engineering, Software Quality
Technical Specialist	Requirements Engineering
System Architect	Software Architecture
Software Manager	Agile, Software testing, Software Quality
Application Analyst	Requirements Engineering
Senior Lead Software Consultant	Global software Engineering, Agile
Owner of Start-up	Agile, Global software Engineering, Effort Estimation, Software Quality
Application Analyst	Requirements Engineering
Software Architect	Software Architecture
Technical Consultant	Software Testing
Software Developer	Agile, Effort Estimation
Project Manager	Agile, Global Software Engineering, Software Quality

In the conducted interviews, each of the interviewee was involved in different roles. They are involved in making different kinds of decisions. Based on the types of decisions taken by them, it is related to the topic that is involved.

5.2.1 OUTCOMES OF THEMATIC ANALYSIS

5.2.1.1 Decision-making factors

As outcomes of thematic analysis, the factors that effect decision-making were obtained. As listed in Table 5, time, organisation goal, trust among the practitioners, need and budget were the factors that were obtained from the conducted interviews.

5.2.1.2 Human factors

The theme "human factors" consisted of the issues that were related to every aspect of decision-making. It was pointed by one of the practitioners that the behavioural patterns of the people may seem to be of low impact on decision-making or bringing change, but they are the ones that should be highly considered because they effect everything. Human factors also play a significant role in implementation of research evidence as it would require their acceptance and adaption.

5.2.1.3 Sources

The sources that practitioners seek for making a decision in industry are also obtained from the thematic analysis results. The sources considered, as obtained from the interview study, are organisation's internal sources, from the experienced practitioners, internet, influencing factors, current scenario and personal opinion. The organisation's internal sources include internal research, teams, meetings, conferences, etc. The practitioners seem to mostly depend on organisational sources for decision-making. Personal opinion involves gut feeling, it was mentioned by the practitioners that were experienced in start-up organisations where majority decisions were taken by them. It was mentioned that the decision is many times made by gut feeling when other factors cannot provide the decision. None of the practitioners mentioned research evidence as a source for decision-making which showed gap between practitioners and research.

5.2.1.4 Organisational activities

Organisational activities could also be obtained from the outcomes. They are the significant factors for any initiation of research implementation in practice.

5.2.1.5 Barriers and facilitators

Barriers and facilitators were majorly gathered and assessed from the interviews as they were the main focus of this study. They were assessed and categorized among the steps of knowledge pipeline.

5.3 DISCUSSION

In the previous study by Kitchenham et al. [1] obtained tertiary study for the number of SLR's published between the years 2004 to 2008. As a updation of that study, a tertiary study has been conducted. SLR's count from the years 2009 to 2016 has been listed. The articles that use the existing evidence in practice, categorized under topics were also listed. It is observed that Agile and Global software engineering are the most popular topics that have the existing evidence which can be implemented in practice.

In order to know the reasons behind this, interviews were conducted with practitioners involved in different areas. After the interviews are

transcribed, the barriers that are hindering the utilization of the evidence in practice and facilitators that help in implementing intervention in practice were listed. As mentioned in the previous sections, survey in the thesis [8] focused on obtaining practitioner's perceptions on research and to find out the barriers in applying research. Although study [8] mentioned some of the barriers, it was constrained to the participants from Norway. The authors, as a result approached different practitioners from different countries and conducted interviews to know their different perceptions in applying evidence. It has also been obtained in this study, just as mentioned in the study by Ree [8], sources that practitioners seek are mostly blogs, internet sources and other such sources away from research results which shows the need for research in the area of bringing a collaborative environment of researchers and practitioners.

The different perceptions of each practitioner helped us to identify and list out the barriers and facilitators as well. Also, the authors gathered many opinions of practitioners on the collaboration between industry and academia side which are presented in Appendix-F. The obtained results from interviews help the future researchers. These results might be adopted in work by other researchers. Conducting the interviews helped us to gain more information. Each of the interviewee listed out their own perspectives. Based on the type of decisions taken by each interviewee, relation is obtained to the topics from the obtained results of tertiary study. Further research could be performed on identifying more barriers and facilitators, apart from the one's mentioned in this study.

In the study [41] by Garousi et al., they have listed the topics suggested by practitioners for researchers to focus on under software testing. Garousi and Felderer, in their work [42], concluded that the focus of practitioners and researchers is varying to a great extent in software testing. Whereas this study has focused on gathering the existing evidence under whole software engineering for facilitating decision-making in practice. Garousi et al. in their study [46] conducted a survey and focused completely on the industry-academia collaboration but in this study the practitioners opinion on "collaboration" facilitating in research for implementation in practice was obtained. Ivanov et al. [47] conducted a survey and mentioned finally that software engineering community requires to perceive the need of industry to reduce the gap between research and practice. In this study, it has been perceived from the interviews that the barriers, in one way or the other, have been stopping the research results being completely delivered to the practitioners, which is represented in conclusion in the form of a figure. This study has also found that facilitators obtained from practitioners could greatly facilitate in smooth transfer of research results to practitioners facilitating decision-making in software industry.

As obtained from Figure 28 that practitioners involved at managerial level access research results, the answers of the interviewees have also showed that the implementation of research results in practice depends to an extent on the managerial level. From the analysis made by comparing the obtained opinions against all the factors, it can be perceived that the factors

such as experience, managerial background, research background, region, and the type of organisation definitely play a major role in implementing research evidence in practice. All these factors have a significant effect of the decisions made in the organisation.

5.4 VALIDITY THREATS

In this section, some of the validity threats faced as a part of this research are discussed. A higher priority is given to the validity evaluation from the initial to final stage of the research process. Two issues such as Validity threat and Validity Analysis are considered. Validity threat is the probability that one would be wrong [60]. Validity analysis is the process of identifying possible threat followed by verifying mitigation [60]. The Validity threats are discussed below-

5.4.1 INTERNAL VALIDITY

Internal validity deals with how causal relationships are examined and relevant conclusions are drawn [61]. Some of the Internal validity threats that are faced during this research process are risk of analysing data in a accurate way is a tough and challenging task, as both the researchers are not experts in the field of research. This was mitigated by continuous analysing of data with the supervisor and also with the help of adequate literature.

5.4.2 EXTERNAL VALIDITY

External validity is used to validate whether the results obtained could be generalized outside the scope of the research [61]. The external validity threat faced was interviews were conducted which could be an issue of generalizability. To make the results applicable, the interviewees were selected from different areas which would help in mitigating this threat.

5.4.3 CONSTRUCT VALIDITY

Construct Validity is considered as a relation between theory and observation [61]. The main Construct validity threat faced during this research process was due to lack of adequate time the survey was not conducted. This was mitigated by conducting more number of interviews than the planned ones.

5.4.4 CONCLUSION VALIDITY

Conclusion Validity relates between the treatment and outcome [61]. The threat faced here is overlooking the required literature. This risk was mitigated by performing two rounds of screenings, which helped in finding out the missed literatures.

5.4.5 SAMPLING BIAS

As the sampling method used in this study was non-probability sampling method, the bias of unknown sampling error may exist [55]. Nevertheless, this error does not severely affect the study as long it does not involve vast data [55]. Hence, it does not impose a significant attention and can be ignored.

6 CONCLUSION AND FUTURE WORK

Descriptions of the conclusions drawn from this study are represented in section 6.1. The future work that can be carried out is presented in section 6.2.

6.1 CONCLUSION

In this study, the researchers performed a tertiary study replicating Kitchenham et. al. study [1]. The results obtained are analyzed using Narrative synthesis. Semi-structured interviews are conducted to explore the facilitators of the use of research outcomes of evidence in decision-making and to explore the barriers restricting the utilization of research outcomes in practice in decision-making. The results obtained are analyzed using Thematic Analysis.

Irrespective of the existing evidence, they are not used and it is mostly because that the practitioners do not see the need or they are not aware of how and where could these results be implemented in their practice.

Research Contributions (RC):

RC .1: An updated version of the tertiary study performed by Kitchenham et. al. [1], which contributes by providing updated existing evidence for knowledge dissemination.

RC .2: The variations in various aspects of practitioners based on factors such as their years of experience, research background and managerial background.

RC .3: List of barriers that are hindering implementation of research evidence in practice. Their categorization under the steps of knowledge pipeline.

RC .4: List of facilitators that promote the use of existing research outcomes and evidence in practice. Their applicability according to the steps of knowledge pipeline

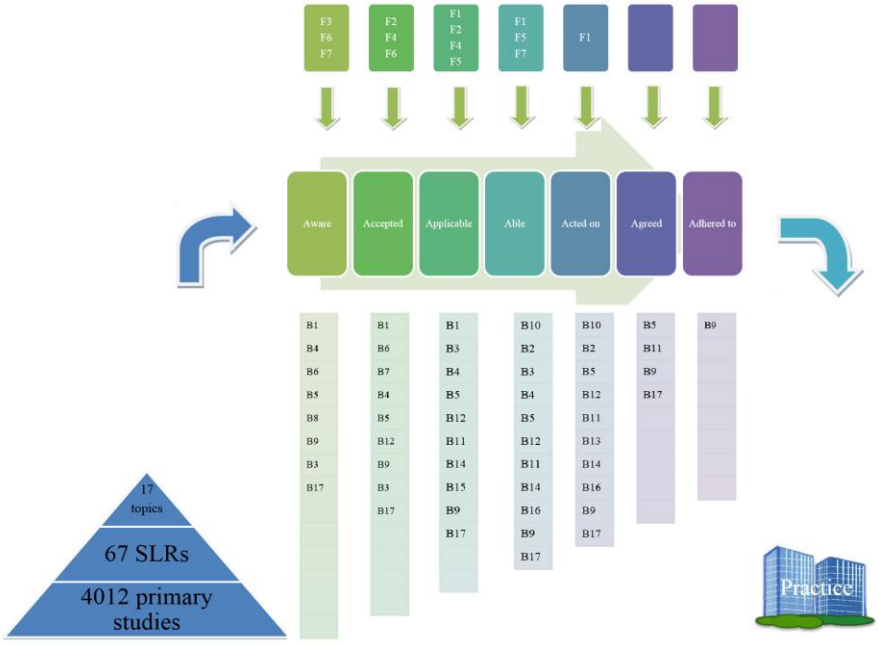

Figure 38: Knowledge flow with barriers and facilitators under the steps of the knowledge pipeline

The Figure 38 represents the final output of this study, the pyramid mentioned at the left is the evidence or the knowledge available from academic research. The knowledge is fully available at the first step “Aware”, which is effected by the barriers mentioned and fullness of the knowledge is not completely delivered to the next step. The knowledge is lost in that way as it flows through the steps till practitioners, and a very little part of the evidence is directly implemented at the end. The facilitators are mentioned on the top of the figure, they are applicable at each step, and if applied, they would help in preventing the loss of knowledge in each step. With the transfer of full knowledge to the practitioner, the decision-making process would get much easier as the barriers are overcome. The obtained facilitators from this study can facilitate in reducing the research to practice gap. As perceived from most of the conducted interviews, it was also clear that practitioners are willing to establish a collaborative environment with the researchers. Collaboration would overcome most of the barriers and facilitate research evidence use in practice.

6.2 FUTURE WORK

It can be observed from Figure 38 that facilitators could not be obtained from the interviews for the last three steps of the pipeline whereas barriers exist in all the steps. Further research can be done focusing on exclusively obtaining facilitators for every step of the pipeline to facilitate the knowledge flow and contribute to reduce gap between research and practice.

The conducted interview study was also limited due to time constraints of the study. Further, there is possibility of extending this research by collecting more sample population and exploring in-depth details of barriers and facilitators.

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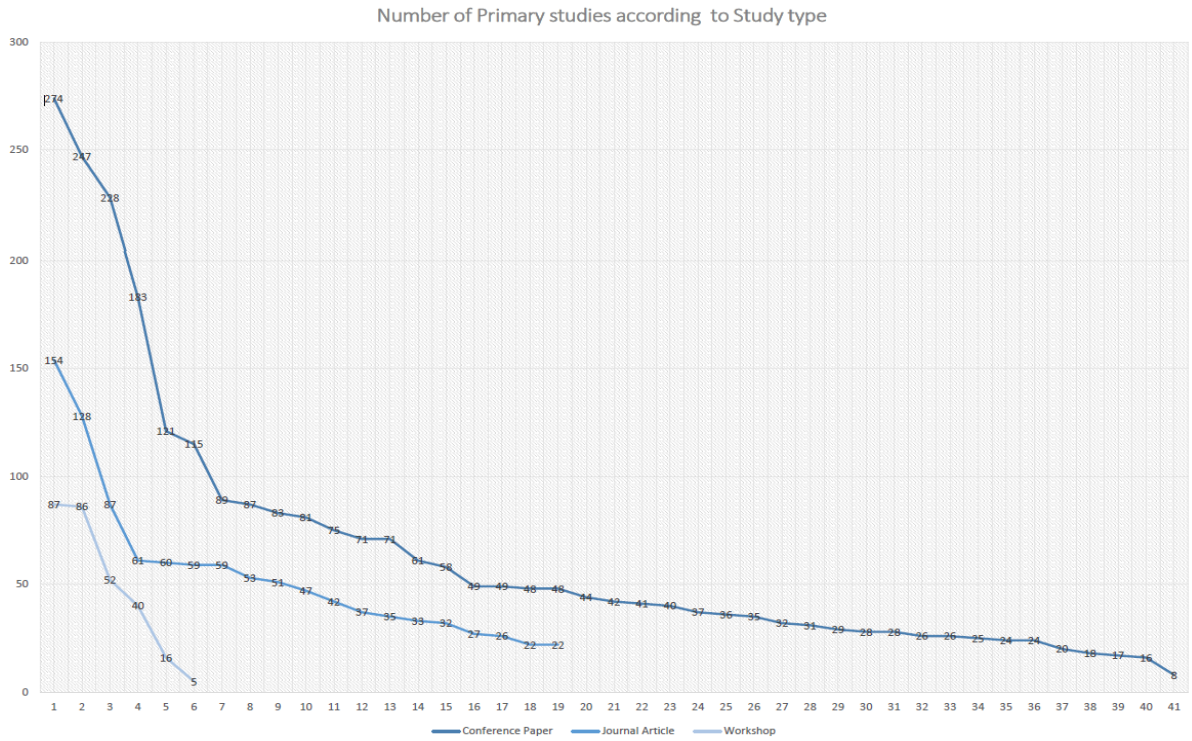
APPENDIX-A

Reference	Database	Year	Is Evidence provided?	Paper Type	Number of Primary studies	Topic addressed
[62]	ACM	2014	Yes	Conference Paper	24	Agile
[63]	ACM	2011	Yes	Workshop	5	Agile
[64]	ACM	2010	No	Conference Paper	183	Agile
[65]	ACM	2012	Yes	Workshop	40	Agile
[66]	ACM	2014	Yes	Conference Paper	71	Agile
[67]	ACM	2013	Yes	Workshop	16	Software sustainability (Quality)
[68]	ACM	2015	Yes	Journal Article	51	Global Software Engineering
[69]	ACM	2013	Yes	Conference Paper	17	Software Architecture
[70]	ACM	2016	Yes	Conference Paper	35	Software Architecture
[71]	ACM	2014	Yes	Conference Paper	25	Effort Estimation
[72]	ACM	2012	Yes	Workshop	52	Agile
[73]	ACM	2015	Yes	Conference Paper	61	Software Testing
[74]	ACM	2013	Yes	Conference Paper	247	Software Architecture
[75]	ACM	2014	Yes	Conference Paper	48	Metrics
[76]	ACM	2011	Yes	Conference Paper	[26 sources]	Software Architecture
[77]	IEEE	2014	Yes	Conference Paper	75	Agile
[78]	IEEE	2014	Yes	Conference Paper	36	Software Architecture
[79]	IEEE	2011	Yes	Conference Paper	8	Software Quality
[80]	IEEE	2013	No	Conference Paper	32	Effort Estimation
[81]	IEEE	2013	Yes	Conference Paper	81	Requirements Engineering
[82]	IEEE	2010	Yes	Conference Paper	49	Software Testing
[83]	IEEE	2010	Yes	Conference Paper	58	Software Architecture
[84]	IEEE	2013	Yes	Conference Paper	83	Global Software Engineering
[85]	IEEE	2015	Yes	Conference Paper	71	Global Software Engineering
[86]	IEEE	2012	Yes	Conference Paper	28	Human Factors
[87]	IEEE	2014	Yes	Conference Paper	24	Effort Estimation
[88]	IEEE	2016	Yes	Conference Paper	40	Human Factors
[89]	IEEE	2016	Yes	Conference Paper	31	Agile
[90]	IEEE	2014	Yes	Journal Article	60	Global Software Engineering
[91]	IEEE	2016	Yes	Conference Paper	26	Software Testing
[92]	IEEE	2016	Yes	Conference Paper	29	Effort Estimation

[93]	IEEE	2010	Yes	Conference Paper	18	Software Quality
[94]	IEEE	2011	Yes	Conference Paper	42	Human Factors
[95]	IEEE	2016	Yes	Conference Paper	20	Agile
[96]	IEEE	2011	Yes	Workshop	86	Global Software Engineering
[97]	IEEE	2015	Yes	Conference Paper	16	Global Software Engineering
[98]	IEEE	2015	Yes	Conference Paper	89	Global Software Engineering
[99]	IEEE	2011	Yes	Journal Article	26	Requirements Engineering
[100]	IEEE	2014	Yes	Conference Paper	37	Requirements Engineering
[101]	IEEE	2013	Yes	Journal Article	27	Software Quality
[102]	IEEE	2015	Yes	Conference Paper	48	Human Factors
[103]	IEEE	2012	Yes	Conference Paper	26	Software Quality
[104]	IEEE	2015	Yes	Conference Paper	228	Software Testing
[105]	IEEE	2013	Yes	Workshop	87	Requirements Engineering
[106]	IEEE	2015	Yes	Conference Paper	41	Human Factors
[107]	Scopus	2016	Yes	Conference Paper	49	Assessment tools
[108]	Scopus	2013	Yes	Book Chapter (Conference)	121	Software Architecture
[109]	Scopus	2014	Yes	Conference Paper	274	Software Testing
[110]	Scopus	2015	Yes	Journal Article	42	Software design notations (for secure software)
[111]	Scopus	2014	Yes	Conference Paper	115	Requirements Engineering
[112]	Scopus	2015	Yes	Conference Paper	44	Software Testing
[113]	Scopus	2013	Yes	Conference Paper	87	Human Factors
[114]	Springer	2010	Yes	Journal Article	59	Global Software Engineering
[115]	Springer	2016	Yes	Journal Article	33	Open innovation
[116]	Springer	2016	Yes	Conference Paper	28	Semantic Web technologies-based support
[117]	Web of Science	2012	Yes	Journal Article	47	Requirements Engineering
[118]	Web of Science	2010	Yes	Journal Article	22	Aspect-oriented programming
[119]	Web of Science	2016	Yes	Journal Article	61	Global Software Engineering
[120]	Web of Science	2014	Yes	Journal Article	53	Software Architecture
[121]	Web of Science	2016	Yes	Journal Article	128	Ubiquitous systems
[122]	Web of Science	2015	Yes	Journal Article	87	Human Factors
[123]	Web of Science	2010	Yes	Journal Article	154	Requirements Engineering
[124]	Web of Science	2014	Yes	Journal Article	22	Software Testing

[125]	Web of Science	2012	Yes	Journal Article	32	Requirements Engineering
[126]	Web of Science	2016	Yes	Journal Article	35	Human Factors
[127]	Web of Science	2015	Yes	Journal Article	37	Agile
[128]	Web of Science	2012	Yes	Journal Article	59	Ubiquitous computing

APPENDIX-B


Number of Primary studies according to Study type
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Conference Paper
Journal Article
Workshop

APPENDIX-C

Decision-making
Could you tell us about your experience in making decisions in industry, if you had any?
What are the sources considered for gathering information to make a decision?
What are the major problems faced in decision-making?
Research results
Do you think that research results can be used to solve the problems faced in decision-making??
Did you ever see any of the research results from academic side being implemented in the industry?
What kind of projects do usually require research evidence?
Is there any procedure followed for implementing the research results?
Do you think research results can be directly implemented to the projects or do they need any modification?
Barriers and Facilitators
Do you refer studies from academic research? (or) Do you think accessing academic research results is hard?
How much does behaviour of customers matter to bring in the change?
How much does usage of research results depend on people behaviour?
How much time does research take to be completely implemented in the industry?
What is your opinion on academic research and industry collaboration? Do you think it can help solve problems?
What are the factors that are hindering research results from being implemented in the industry?
Could you please tell us what kind of factors can promote academic research in industry?
Awareness
Are the practitioners aware of the existing research evidence?
In case, the organization takes an initiative to implement the academic research, will the practitioners be ready to accept it?
What do you think academic research can do to improve the trust among practitioners?
Do you think research evidence can reduce uncertainty and fear in decision-makers?
Do you think anything can be done to increase awareness among practitioners?

APPENDIX-D

S.No.	Agile	The evidence/output provided
1	[62]	The result was on Agile practices that suit practitioners' needs: Frequently implemented practices: daily stand-up, iteration planning, release planning, and retrospective. Less frequently used: progress-monitoring, burn-down, unit testing, quality check
2	[63]	Agile practices in scientific software development: Scientific software require special characteristics of requirements and testing, it was found from the literature review that agile practices suit scientific software development, and hence agile practices can effectively handle requirements and testing with special characteristics.
3	[64]	Practitioners seem to publish (about 66%) more than academics in agile studies. The experience based work is more than empirical ones which reduces uncertainty on the evidence.
4	[65]	XP and Scrum were found to be the regularly applied agile approaches in embedded software development. There is about 35% literature concerned with implementation of agile approach in mobile application development.
5	[66]	Agile and User Centered design (UCD) integration success factors were listed for each challenge faced such as lack of upfront time, design chunking, difficulty of prioritizing, lack of documentation and so on with modifying upfront design, design goals, responsibilities, documenting etc.
6	[72]	Mentioned XP's benefit and issues towards automated testing, and mentioned unit testing and early and frequent testing could give partial solution. Performance issues were handled by combination of TDD (test-driven development) practice with TFP (test-first performance). Presented the use of agile approach for peculiar features of embedded software enhanced by XP and User-Centered Design methodologies, also benefitting large projects with short duration through frequent release of early working versions.
7	[77]	Found that issues like time zone problems, need for sophisticated coordination tools and, distributed environments' quality problems are less focused in large scale distributed environments with agile. The awareness of cultural readiness, training and knowledge transfer is highly essential among the stakeholders for bringing forth large scale/distributed agile development.
8	[89]	Human-computer Interaction technique names adopted by agile software process development requirement engineering activities, with reference to the literature are given.
9	[95]	They have listed practices and challenges in Agile methodology requirements engineering through literature review and have also suggested possible solutions.
10	[127]	Most of the studies focused on Lean, the studies reported Kanban approach as the most frequently used lean practice, and as direct implementation of lean product development. The Kanban approach use, the principles agreed, its effectiveness on deriving and leading organizational changes were given.

S.No.	Software Architecture	The evidence/output provided
1	[69]	Presented existing solutions for fault-tolerant SOAs and discussed their main contributions and limitations.
2	[70]	Identified thirty-five studies that presented existing metamodels in the literature that provide support to PLA design phase. 80% of the metamodels represented the variability using UML, some of the studies simplified the UML class diagram, some others extended the UML representation. Only a small part of the studies (5 out of 35) discussed the binding time representation that the binding time representation to detail the architectural variability in depth.
3	[74]	About 60% of the studies are case studies and the major problem that they encountered was poorly reported case studies and that most of the research is going on in academia as much as 62%. Industry's contribution was 13% and 25% studies were of industry and academia collaboration.
4	[76]	Combination of effective techniques from ATAM, ALMA, and supplemental methods were suggested for a good sustainability architecture review. Listed more than 40 architecture-level metrics.
5	[83]	Benefits of architectural quality evaluation methods, economic valuation methods, architectural knowledge management and modelling techniques on software architecture quality requirements, architectural decisions' business, architecture documentation, and architecture evolution were presented.
6	[108]	There is less evidence involved in research on architecture-based self-adaptive systems with not much of industrial applications.
7	[120]	Classified software architecture visualization techniques (VT) into four types: graph-based, notation-based, matrix-based, and metaphor-based. Popular ones discerned were graph-based and notation-based techniques. The architecting activities supported by each VT category and their purpose in architecture was given. There was a lot of industrial level evidence in the literature reviewed.
8	[78]	Obtained three categories of approaches that tackle runtime NFPs (non-functional properties) in SPLs (software product lines). Majority of the studies involved case studies, few had real-world products and there was improper application of methods. The outcomes assured a high scope relevance of NFPs for next generation computing applications.

S.No.	Requirements Engineering	The evidence/output provided
1	[81]	RE issues, challenges, best practices and effects have been given. Elicitation issues have been classified.
2	[99]	Collected empirical evidence on elicitation techniques. In spite of the issues from diversity of the tested elicitation techniques, response variables, experimental contexts, they proceeded to collect empirical results resulting in a concrete evidence. Framed five guidelines for the practitioners.

3	[100]	The issues reported in the literature were used to categorized SLRs under prioritization, elicitation, stakeholders, security, creativity, and miscellaneous.
4	[105]	Dealt with user involvement in software development. Suggested additional resources, careful management and involvement in early development phases for obtaining the benefits. Design and implementation phase involve decision-making process requiring political dimension of user involvement. There is less empirical literature on user involvement which leaves no guidelines for further analysis. User involvement in requirements analysis phase can result in system success as extracted from 13 studies.
5	[111]	Requirement prioritization techniques are listed against technical aspects and business/client aspects, showing which aspects does each technique satisfy.
6	[117]	The best practices and issues of stakeholder identification are listed.
7	[123]	This study aimed in structuring and evaluating research work on empirical requirements engineering. In this process, resemblance to EbM was obtained, which is an approach used in computer science and BISE.
8	[125]	The studies showed industrial implementations, they showed that activities vary regularly, followed by artefacts and roles. Processes were varied using operations like delete or insert, and element (definition) in all the literature. The literature contains details on obtaining a tailored (specific) process after the tailoring, for which, many studies suggested tools support for tailoring and knowledge storing.

S.No.	Testing	The evidence/output provided
1	[73]	Provided a list of environmental model advantages in benefitting robustness testing, safety testing and regression testing. The modeling languages in which it was studied were given. The limitations and current challenges in testing with environment models were summarized. In spite of ease in automation of test case generation through environment modeling, some test cases are written manually.
2	[82]	Showed evidence of component-based software engineering (CBSE) and testing in the field of embedded systems.
3	[91]	Identified papers in Acceptance Test Driven Development (ATDD) are listed. The imperfect acceptance tests are beneficial, significantly mentioned tool from literature was Fit/FitNesse, lack of research exists for asynchronous applications, and the analysis and comparison of ATDD research results with traditional manual tests is necessary.
4	[112]	Did not come across industrial applications in CRC, showing no changes to Petersson's study. Software engineering utilizes four CRC models. The number of inspectors, their capability and difficulty of defects detecting, have vital impact while adopting CRC method as well as carrying out experimental studies on CRC.

5	[109]	The most used method was Usability Testing and most used techniques were usability tests, questionnaires, and heuristic evaluations in three years span. Observed confusion between (a) Usability Tests and (b) Thinking Aloud and concluded that the studies referred same technique.
6	[104]	Determine that frequently imposed techniques are: questionnaire, user testing, heuristic evaluation, interview, and thinking aloud protocol. The applications from literature were under categories of Health Informatics, Education, Software Development, E-Commerce and Gaming.
7	[124]	Logical or mathematical representation of the models, such as UML class diagrams, along with OCL constraints, are used to formalized. Verification tools to impose techniques were mentioned by some studies, which have diverse effect based on OCL usage.

S.No.	Software Quality	The evidence/output provided
1	[79]	Software process improvement models/techniques are used by small and medium Web development organizations. Tabulated Software process improvement models/techniques that were successful through mapping of the models/techniques with determinants and measures of success.
2	[93]	Empirical evidence of quality requirements was obtained showing that dealing with quality requirements' dependencies is easier using tools than manual approaches. Three dependency methods were identified.
3	[101]	Academic subgroup effect size is greater than that of Industrial. Productivity had no increase by the industrial experiments. Developer experience and task size are two of the significant variables. Task complexity values inversely effect quality improvement. Suggested that TDD results in a slight quality improvement but productivity results are hard to decide.
4	[103]	SPI improves team communications, and thus knowledge sharing, positively impacts developers, but it can also have negative impacts, such pressure on developers to document with no discernable use.

S.No.	Effort estimation	The evidence/output provided
1	[71]	In an Agile Software Development (ASD) context, effort or size estimation techniques, effort predictors used in estimation studies, dataset characteristics, and investigated levels of agile methods, activities and planning. Techniques most used are expert judgment, planning poker, and use case points method, most used size metrics are story points and use case points. Most of the techniques have not resulted in good prediction accuracy values., Industrial project data was used for most of the estimation studies.
2	[80]	Estimations help in planning and tracking project. Popular approaches are model-based, monitoring based and expert-based estimation. There are not many studies to provide analysis on estimation results, on using benchmark data and composite models. To obtain accurate estimates in each iteration/release, the ongoing data is preferred in estimation models than the historical

		project data.
3	[87]	Effort estimation approaches have been used in the context of globally distributed projects without any kind of adaptation. Expert-based effort estimation approaches are generally preferred by practitioners but there is no standard approach. There is a lack of research about effort estimation in offshore outsourced projects.
4	[92]	Literature review was performed to obtain effort estimation approaches in OSS. Linear regression model was the most frequently used by studies that predicted indirect effort of an entire OSS project. Manpower function method was widely used to predict direct effort of OSS projects. Decision tree, Logistic regression, and Naive Bayes were frequently used methods for predicting effort of maintenance activity.

S.No.	Global Software Engineering	The evidence/output provided
1	[68]	The best practices, challenges and tools for GSD teams are listed and tabulated with clear references to the literature. Finally, the success factors are also listed.
2	[84]	In initial results, the frequently mentioned project management challenges are given. They also discussed how one challenge impacts and leads to other project management challenges.
3	[85]	Listed challenges in implementing requirement engineering processes throughout the organizations in context Global Software Development. Also mentioned frequency with respect to different time periods. Listed five critical factors as well.
4	[90]	Listed 11 intercultural challenges in total faced by vendor organisations in OSDO (offshore software development outsourcing) relationships. These critical intercultural challenges are: ‘language and language proficiency’, ‘national culture’ and ‘organisational culture’.
5	[96]	Gathered challenges associated with GSD projects as well as their mitigation strategies through systematic review as well as survey.
6	[97]	This mapping study indicates that the application of software cost estimation techniques for GSD projects is quite unsophisticated in both research and practice. Gave software cost estimation activities, cost drivers and cost performances.
7	[98]	Factors that are vital prior to integration phase and the success factor during integration phase are listed. Vital factors in all stages of integration are “Intra and inter team Communication and Coordination”, “Proper Documentation & Configuration Management” and “Early Integration Planning and Centralized P3 management”.

8	[114]	The empirical studies in GSE are still less in number. Most of them emphasis problem-oriented reports under various aspects of GSE management rather than thorough evaluation of practices or techniques. Seven most frequently discussed practices are obtained which are inversely proportional to cost reduction strategies and are prerequisites for organization success.
9	[119]	Offshore-outsourcing collaboration model was dominant in GSD. Challenges and practices in GSD are classified into 6 main themes.

S.No.	Human Factors	The evidence/output provided
1	[86]	The synthesized evidence shows that dispersion dimensions do not directly impact team performance but indirectly via team coordination problems. They reduce communication frequency, created coordination delays and misinterpretation in lateral communication. Overall it has a negative impact on performance of distributed teams, in both subjective and objective measurement.
2	[88]	Gave table mapping each environmental factor to the literature. The task itself and the organization will affect the individual decision-making behaviour from more aspects than those of other categories. The influences coming from a software team must not be overlooked.
3	[94]	Suggested not use to the results directly in practice as there are contradictory evidences showing lack of maturity in research. The evidences are weak and in many cases inconclusive.
4	[106]	Found 15 papers reporting factors that influence on various team process dimensions in software engineering teams. Action processes, the team activities involved with direct goal contributing tasks, had no studies showing pessimistic review of individual characteristics over the performance. Transition processes are the periods of time when teams focus primarily planning activities in which slight evidence could be obtained on performance influencing factors.
5	[126]	The term “teamclimate” was not mostly used in studies but they focused on the relationship between the personality and team performance. The alternative terms used in place of "teamclimate" are tabulated. The third RQ results showed that project team characteristics have a significant impact on software team performance. The fourth RQ focused on identifying different ways of measuring team performance.
6	[102]	The most cited human factors were: Communication (23 papers), collaboration (6 papers) and trust (8 papers). There were four exceptions found in the study which regardless of their significance in agile methods, they plainly obstructed to adopt these methods.
7	[113]	Overall results are showing a positive reflection of user involvement on system success. Classified the studies according to research method and analysed relationship factor.
8	[122]	Extensive study is done, analysed relationship among the literature and gave the proportion values. Benefits, problems and challenges obtained from the literature are listed with clear descriptions. Various aspects of managing users, and their level and extent of involvement in different stages of software development under different conditions is given.

S.No.	Other	The evidence/output provided	Topic
1	[67]	Only the characteristics such as Performance efficiency, Maintainability, Portability, Usability, Reliability consist measures to apply for the product quality characteristic. Gave the potential reasons for having only two quality-in-use measures.	Software sustainability (Quality)
2	[75]	The most frequent techniques from the formulated prediction models were Naïve Bayes and Logistic Regression. Prediction results were analysed using many metrics. The predictor aspect of social metrics was reported by few studies. The author has not made further assumptions as literature is insufficient.	Metrics
3	[107]	Assessment Tools for Programming Assignments are listed in table against different Main Features, Types of Verification, Interfaces and Programming Languages, and appropriate ones are marked.	Assessment tools
4	[110]	Notations are listed with references, scope and tool support. Suggested that this work can be "buying guide" to software architects and design teams to know the techniques to use.	Software design notations (for secure software)
5	[115]	Conflict between agile and OI (open innovation) principles was identified the attention for it was put forward. OI strategies seemed to benefit newly arrived actors in a market. OSS and OI were mentioned as not free and OI requires different IPR management.	Open Innovation (OI)
6	[116]	Semantic Web technologies-based support for the standardization of the Software Engineering discipline is less. Major motivations for their use is: (1) to understandably mention the domain concepts and to frame domain conceptual models, (2) to integrate different concepts in multiple domains; (3) to promote SE knowledge management across a domain.	Semantic Web technologies-based support
7	[118]	In comparison with non-AOP approaches, AOP has promising effects on performance, code size, modularity and evolvability related characteristics. The drawbacks or the neutral effects were on exception handling in language mechanism, and cognitive dimension of software development.	Aspect-oriented programming
8	[121]	Classified the approaches depending on software development life cycle phase and, the main target of the approach. Identified eight phases in the development cycle. Identified the main approaches and the limitations.	Ubiquitous systems
9	[128]	The definition and the characteristics of Ubiquitous Computing were updated, and functional and restrictive factors pertaining to each characteristic were identified.	Ubiquitous computing

APPENDIX-E

Analysis of interviewees based on their career background

Interviewee	Practitioner	Has research background	Aware of current research	Implementing research currently
Interviewee-1	Yes	Yes	Yes	Yes
Interviewee-2	Yes	Yes	Yes	Yes
Interviewee-3	Yes	Yes	Yes	Yes
Interviewee-4	Yes	No	No	No
Interviewee-5	Yes	No	No	No
Interviewee-6	Yes	No	No	No
Interviewee-7	Yes	No	No	No
Interviewee-8	Yes	Yes	No	No
Interviewee-9	Yes	No	Yes	No
Interviewee-10	Yes	No	No	No
Interviewee-11	Yes	Yes	Yes	Yes
Interviewee-12	Yes	Yes	Yes	Yes
Interviewee-13	Yes	No	No	No
Interviewee-14	Yes	No	Yes	No
Interviewee-15	Yes	No	No	No
Interviewee-16	Yes	Yes	Yes	Yes
Interviewee-17	Yes	Yes	No	No
Interviewee-18	Yes	No	Yes	No

APPENDIX-F

DECISION-MAKING	ANSWERS FROM INTERVIEWS SUMMARIZED
Could you tell us if you had any experience in making decisions in industry?	Involved in creating playground for decisions, decisions under "techno-functional" aspect which means a hang on coding as well as in business aspect, decisions made within the scope of their organization, along with higher management, critical decisions that are specific and crucial to my organization, technology decisions and architectural decisions, higher management is followed.
What are the sources considered for gathering information to make a decision?	Previous experiences and results, trust, gut feel, according to needs, resource and money-making dimensions, making it cheaper, smarter, small and effective, external reports and consultancies that go in and do probes and do investigations, people management, the right person, who is expertise into that level, videos, presentations, new trending things and articles on the internet. On technical side, properties of the technology and performance. Maintenance is another factor.
Is there any prioritization or categorization of decisions in the industry?	There are formal as well as informal ways of decision-making. Decisions are on different levels. There are many teams, where each team can't take own decision. Depends on size and structure of project, customer need, investment, architecture, implementation decisions, verification testing decisions and severity and impact. Sometimes companies put on teams or responsibilities to do the decisions.
Is there any specific procedure followed for decision-making?	There are different processes followed for decision making, such as usage of tools, usage of methods like Cost Benefit Analysis and decision analysis and resolution, method called "plus or minus", especially in terms of the project execution in critical areas. The large company have sophisticated decision-making processes in general. It seems like due to hierarchy and many other things, there risk of dying is less. It's not so much fear of making the wrong decision but in smaller companies, it's more fast trial and error. It is more risk focused here.
While making decisions, there are factors such as time, do they matter?	Sometimes it takes long time and quite costly, sometimes, it can go fast. If the design is ready and you are about to start implementation, then it can go fast as design is available, but finding the right design may take lot of time. Depending on money that is involved, the amount of people in the organization. If it's large re-organizations or organizational impact then it takes lot longer time. Time is crucial, scope or the content is also important. It depends upon scenario to scenario, usually it involves a lot of brain-storming and then collection of views of various stakeholder's, so, it takes between 4 hours- 15 hours for a video call decision, I'm not considering the time-lags. There are decisions where there is time taken for about more than two and half and three months to be decided. It depends on the personality of the person whose is proposing a decision or the change.

Is there any specific team assigned for decision making or everyone is involved?	It depends on kind of decision you are taking. Hierarchical structure matters, technical manager is responsible for taking these kind of decisions. But it's quite seldom that this person does that, it's just if the problem agreeing solution is quite necessary. Sometimes, around less than 10 people are involved, when the department size is around 250-250+.
What are the major problems faced in decision-making?	Lack of knowledge. Deep human psychological behaviour and mechanisms are probably the biggest obstacle for efficient implementation of decision-making. The complexity of the problem that has lot of people involved. It might be that the decision is made in a part where people are affected but that is over looked. That case, we would notice the problem very late in development cycle. Approval of everyone is one of the biggest tasks that is involved in decision making. Risk factor that is associated with the decision making.
How often are decisions taken?	Time in industry is money, and it also involves different countries in some companies, hence time should be carefully utilized, because product is paid in time per hour.
RESEARCH RESULTS	
You have mentioned some of the problems faced in decision making? Do you think that research results can be used to solve those problems?	I think "academic" research can provide knowledge but I don't think it can provide the actual decision itself. It's more like being part of the context around the decision. Research results can only guide the person involved like in a much more matured manner, but research results cannot only give you a hardcore suggestion. There are lot of factors that influence a decision. But yes, it will certainly help in making decisions. Yes, as universities involve lot of young students, there are definitely very good fresh ideas. There are ideas which are out of the box, because we, practitioners, are constantly focusing on one aspect for long time.
Did you ever see any of the research results from academic side being implemented in the industry?	Yes, good collaboration between students and industry about 75-80%, all of the research has not been used but learnings from the research are being used to an extent but, it's very less as of now, there needs a lot of support for research. There's also a lot of complexity, the simple and easy to use ones are used. Most of the research has been internal like the historical data and statistic ones. So, we have that kind of research but yeah study based research was not done and parallelly some research is done in the department. Not to a large extent. I am not sure about the research results from academic side. I never referred to them or did see anyone referring them.
What kind of projects do usually require research evidence?	Software developers always aim to develop the product smarter, better and cheaper. The thing I have seen is that I do it very close to kind of basic research, how thing transfers to different medias and such low level stuff. So, I think I have experienced lot of things of research both this low level frequencies, amplifications and how you connect things in safe manner.

Is there any procedure followed for implementing the research results?	Management commitment Find appropriate researchers who would be interested in doing research in this area Constantly reassure to reaffirm the research objective and it will move Be owners of the research objective, which is the tricky parts in research collaboration.
Do you think research results can be directly implemented to the projects or do they need any modification?	Yes, most of the things in research are not tried in the industrial kind of environment so the results would require modification. Sometimes limitations are not stated in research studies. I don't think they can be directly implemented, they should be piloted first in one or two projects, check the inferences and check also the stability of the methodology and then check the correctness of the research results and also the impact. When you do that, the results show you proper data, proper stability and at that point of time you will be able to launch it in the industry where directly it can be implemented in projects.
Is there always a separate research team which works on developing the innovations or does it rise up among the developers?	It depends on the company. Some developers privately meet in their free time out of working hours to get their individual ideas into implementation.
As you said, there's technical side as well as the business side, we heard that there has been no research on business side, is it true?	Absolutely true. If you have any bug in your product, you should have good business idea and strategy, it's very much important. These are the big pillars of any industry, business and technical. I can say, you can't remove a business guy saying "I don't need a business idea, I can develop something and I can give it", no. At the same time, I have a very good idea, but don't know how to implement it, we just can't do it. So, both are very important in any industry.
BARRIERS AND FACILITATORS	
Do you refer studies from academic research?/ Do you think accessing academic research results is hard?	In most of the things we do, we do not need software or software engineering research. We rather need business support research which no one does. That is nowhere to be found in the world. Every company says "we know our processes is best and no should tell how we should do it, we have been doing this for years, we know the right thing, you don't need to tell us". Time taking with little outcome, research papers structure, I think this is academia's biggest problem, how to make research results contextual so it can be reused not only by industry but also in other researches. And as these areas grow and become more kind of cross disciplinary with human behaviour, management, etc,. Everything should be open source that we use, so we go to the open source community to find, and there are also articles, descriptions and so on.

Does it also depend upon the behaviour of customers to bring in the change?	The customers also require change, and the market situation forces change. But the main thing that changes is not the software, it's not software engineering, it's business support. There are lot of customers that require us to participate in research. It has to be thought about the whole thing, it's not just developers and the team. For the ones that are going to use on the other side of the API. Also, those doing the user-interface, how's it going to effect them and so on.
Does usage of research results depend on people behaviour?	Many feel threatened by things that will disturb reality. It depends upon the geography, culture, and the pattern of employment. The behaviour patterns of people change and it matters. Some agree with this. Some teams prefer to work in their old way. They are scared of change from each region. They don't want to change their rhythm. If the person who wants to implement the change sees a huge benefit, they won't agree with that change.
We have seen in a study that research takes about 10 years to be completely implemented in the industry. Have you seen this happening?	It's going faster now, Google does lot of research, they post many papers. Sometimes the results are used before they are published. They take lot of time to publish so after they are published, they might be quite old. Sometimes it might be useful but not timely. It is implemented on a slow pace, because it's not technology side, it's humans' perceptions as well. So, it takes trust, when it comes to money, no one wants to trust. Others are coming faster than results are published. There were a lot of things which were not clear for all of us years ago. And yeah, though it takes ten years it is certainly useful. But all the technology or all the implements which we are seeing right now are certainly outcomes of the research that has been done about 7,10 or 12 years ago. Because for research to become commercial, it takes time, there should be certain proof, usually people will be investigating on research, until it's proven.
What is your opinion on academic research and industry collaboration? Do you think it can help solve problems?	In reality, having the knowledge will still not help this problem. Industry and academia has to collaborate, because industry has the good understanding of defining a gut feeling of what is the real problem and at what level should we define the problem. Academia should use their cleverness, their time for reflection, their experiences from different fields to help industry define the real problems. The research and academia could really need to start understanding that both are equally important and they should not really compete. It has huge impact, academia should know what's going on in industry. I truly believe that research without a connection to industry is hard. Strong collaboration between company and academia would be best according to me. I think companies should not be saving the money but should be paying for research. That would help because people think from a different perspective in that particular study. It would be much more useful if the research is done in the industry with global presence so that there wouldn't be any redundancies and effort can be efficiently used for new innovations.
What are the factors that are hindering research results from being implemented in the industry?	Written in academic point of view which is not understood easily. Most of the text is about surroundings, why it came and so on. But exactly what is done is not always explained clearly. Uncertainty. Being in comfort zone, because we are good at what we are doing, we don't need to change. Additional help. The models produced by academia often discard ambiguous terms such as culture, human behaviour, etc. which are major problems. Company culture doesn't allow. It's so academic that, they explain things in such detail that you are not really interested in the algorithm that they use. If they say they solve the problem, we trust that you solved the problem while testing it. Lack of maturity. Vast number of papers. There is no habit of reading anymore.

Could you please tell us what kind of factors can promote academic research in industry?	Available, open-source, organized, early released, industry tested, easy to use with frequent release for usage and interestingly presented research results. One thing important is personal relationships. Knowledge relationship. Open-mind, being comfortable with research. Agree on problems, address problem definition more systematically. The conflict of long term from academia and short term of industry should be dealt by dealing with the ever-increasing speed and information in its context. A collaboration that needs to be done, but the main factors are ecosystem, hierarchy, then scale. So, motivating the industry with research is a facilitator. Collaboration is one of the things that makes biggest impact on what we choose. Spreading the awareness of the existing evidence.
AWARENESS	
Are the practitioner's aware of the existing research evidence?	It is not initiated by most of the companies. Many said only few ones interested on their individual interest. The ones with research background mentioned the reason to be no good forums for dissemination. The way academia today is re-enumerated or incentivized is basically writing as many papers as possible. Some extreme practitioners with no touch with research said that the level is different and they are totally unaware of present research.
In case, the organization takes an initiative to implement the academic research, will the practitioners be ready to accept it?	It's communication among people, how you create the common vision. One interviewee has even mentioned a practical experience. It is a cultural issue, it depends in the culture of the organisation, if they initiate, there are practitioners who wants to follow the research results. But, not everyone of them because of other reasons. It's not that the research results are wrong but may be the methodologies and the procedure to implement, the solutions of the research results are tough, that is another factor. But if it changes the way of work, then people matter and it depends on people mindset.
What do you think academic research can do to improve the trust among practitioners?	It might be a brilliant idea but in order to actually know that this is going to work, you need lot more people who try it out, who adopt it, play with it, see the flaws, fix the bugs, and then they consider it a good idea. That's where maturity can come in. They have been implementing it in Melbourne a lot, and results have been good.
Do you think research evidence can reduce uncertainity and fear in decision-makers?	Some answered yes, and some that if it can prove that it's good then it can reduce. Some said if it's not essential, wait and others doing and can take it and do it your own way. It depends upon what the project is about and its value.
Do you think anything can be done to increase awareness among practitioners?	Managerial style, willingness and confirmation. It's much more of match making and then how do I find the proper academic research, I need to filter that as well as it would be useful to me. Then we are also back to networking dimension.

APPENDIX-G

Word	No. of interviewees
team	16
management	15
experience	13
time	13
collaboration	12
customer	11
implement	10
need	10
people	10
behaviour	9
company	8
trusted	8
aware	7
business	7
industry	7
project	7
requirements	7
academic	6
cost	6
money	6
open	6
person	6
publish	6
valid	6
communicate	5
complex	5
culture	5
deliver	5
delivery	5
development	5
expert	5
hard	5
interested	5
opinion	5
product	5
responsible	5
client	4
early	4
format	4
goal	4

internet	4
invest	4
language	4
perspective	4
practitioner	4
prioritization	4
procedure	4
relationships	4
role	4
system	4
think	4
academia	3
change	3
deadline	3
environment	3
experienced	3
feel	3
humans	3
individual	3
influence	3
innovate	3
internal	3
involved	3
knowledge	3
managerial	3
mature	3
meeting	3
risk	3
security	3
technology	3
tested	3
understanding	3
agree	2
articles	3
atmosphere	2
availability	2
behavior	2
believe	2
care	2
ceo	2
cheaper	2
circumstances	2
commitment	2
competitive	2

consequences	2
control	2
correctness	2
define	3
delay	2
efficiency	2
expect	2
expertise	2
fast	2
finance	2
financial	2
forum	2
funding	2
group	2
hierarchical	2
hierarchy	2
hire	2
honest	2
improve	2
lack	2
methodology	2
mind	2
organization	2
priority	2
profit	2
quality	2
standard	2
strategy	2
structure	2
talk	2
tell	2
transparency	2
true	2
uncertainties	2
update	2
vague	2
verification	2
vision	2
years	2
ability	1
advantages	1
agreement	1
ambiguity	1
animation	1

applicable	1
ask	1
awards	1
background	1
beginner	1
behave	1
benefit	1
blogs	1
budget	1
capacity	1
carrier	1
categorization	1
cheap	1
checked	1
checkpoints	1
choice	1
collaborately	1
comfortable	1
competency	1
conclusions	1
conditions	1
confidence	1
connection	1
content	1
context	1
core	1
creativity	1
critical	1
decisionmakers	1
dedicate	1
degree	1
deliverable	1
devoted	1
different	1
disagreement	1
discuss	1
dissemination	1
doubt	1
duration	1
emergency	1
ensure	1
established	1
evaluated	1
expensive	1

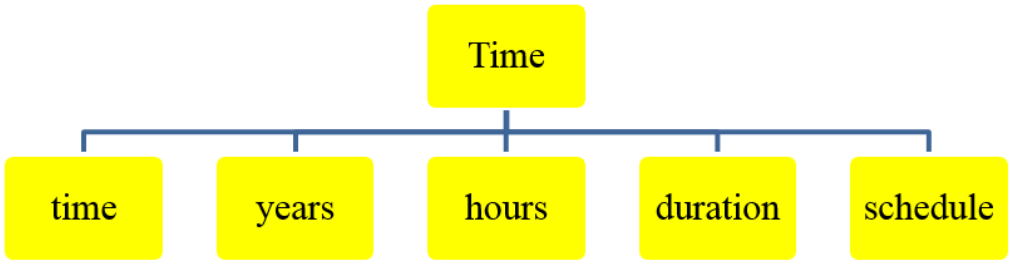
factors	1
facts	1
faster	1
fear	1
feasibility	1
focus	1
free	1
fresher	1
friends	1
genuinity	1
government	1
graphics	1
guidance	1
guided	1
guidelines	1
gut	1
hear	1
hours	1
inclination	1
inside	1
interact	1
interconnected	1
interpret	1
investor	1
irrelevant	1
leadership	1
license	1
listen	1
media	1
members	1
mentor	1
mindset	1
misconception	1
modification	1
motivating	1
networking	1
new	1
newbies	1
objective	1
patience	1
perceptions	1
position	1
potential	1
practitioner	1

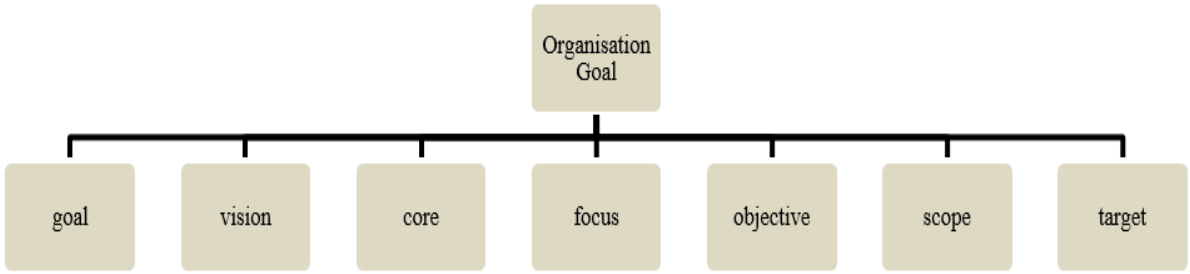
pressure	1
professionals	1
proof	1
prove	1
psychological	1
purchasing	1
quantity	2
quick	1
quicker	1
rapidly	1
reality	1
reapplied	1
recognition	1
rectify	1
relevance	1
religious	1
re-planning	1
repository	1
re-strategizing	1
retrained	1
reusable	1
reused	1
right	1
rigorously	1
risky	1
salary	1
sales	1
satisfaction	1
saying	1
scenario	1
schedule	1
scientific	1
scope	1
selling	1
size	1
specialist	1
specific	1
speed	1
spend	1
spent	1
stability	1
stakeholders	1
suitable	1
synchronized	1

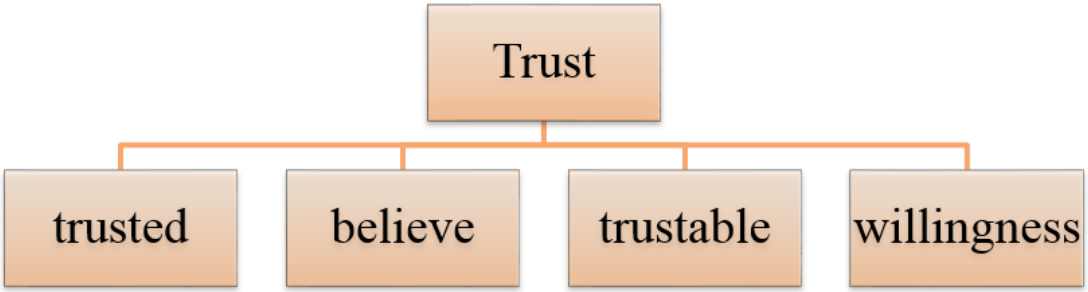
systematic	1
target	1
technicians	1
theoretical	2
threats	1
together	1
traceability	1
traditional	1
trainer	1
training	1
trend	1
tricky	1
trustable	1
truth	1
unavailability	1
uncertain	1
unclear	1
unconfirmed	1
urgency	1
valuable	1
vendor	1
video	1
visual	1
vocabulary	1
voice	1
willingness	1

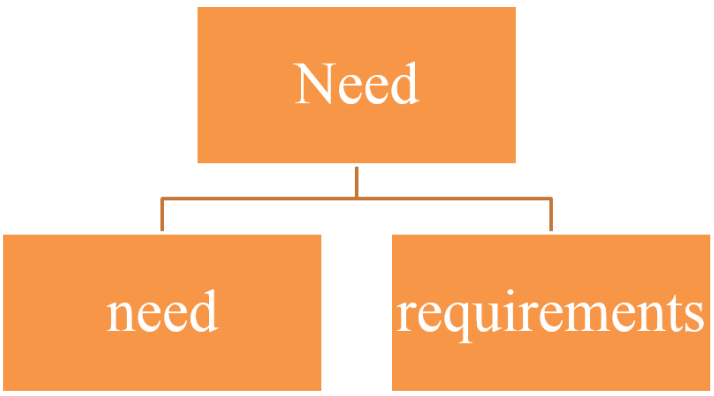
APPENDIX-H

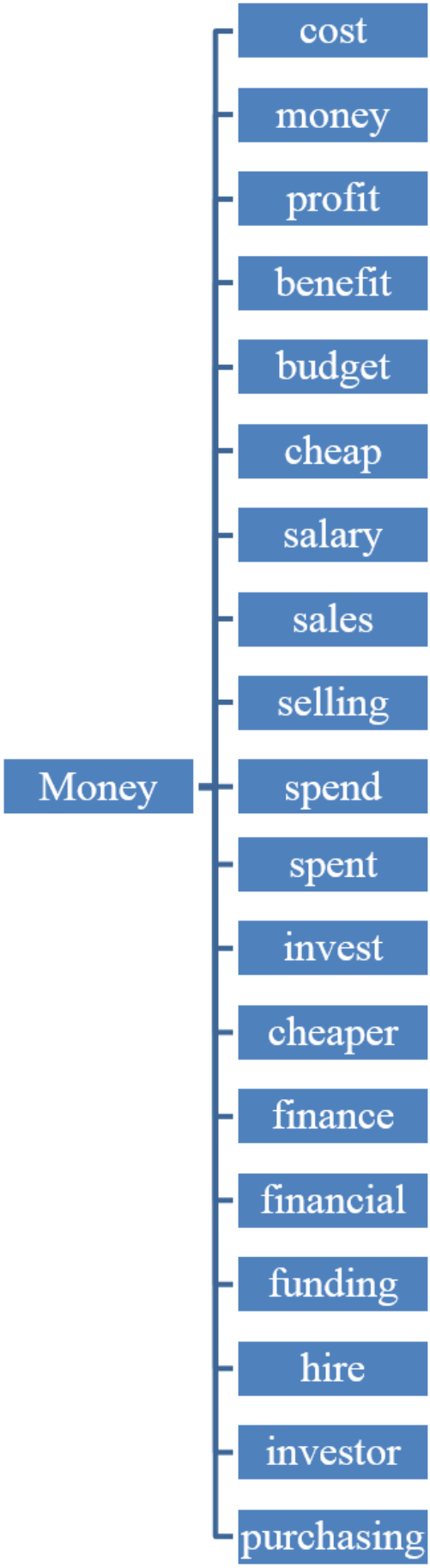
FIGURES REPRESENTING THEMTIC NETWORK OF OBTAINED CODES AND THEMES

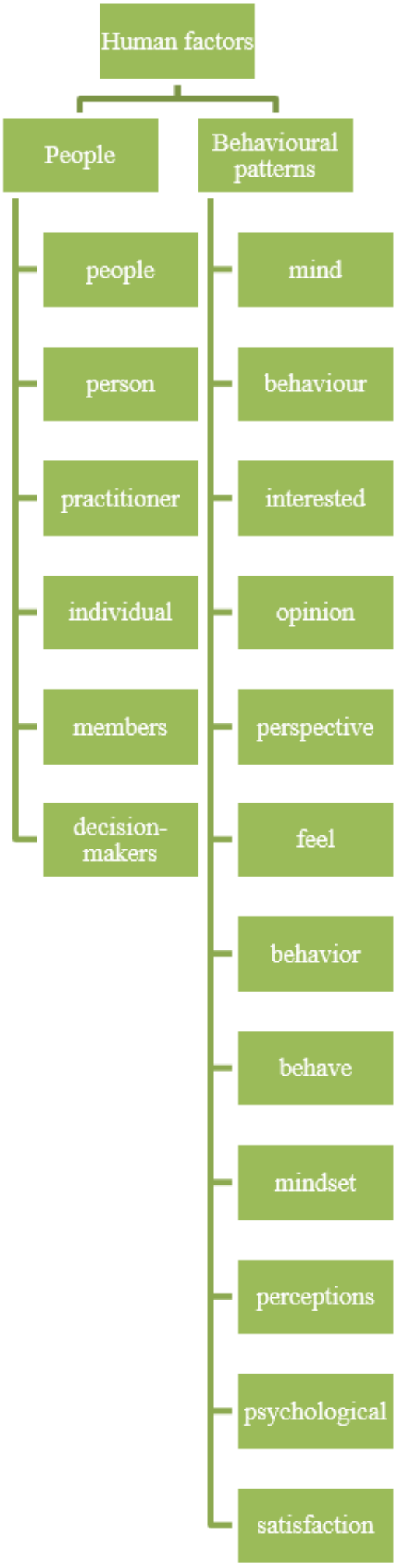


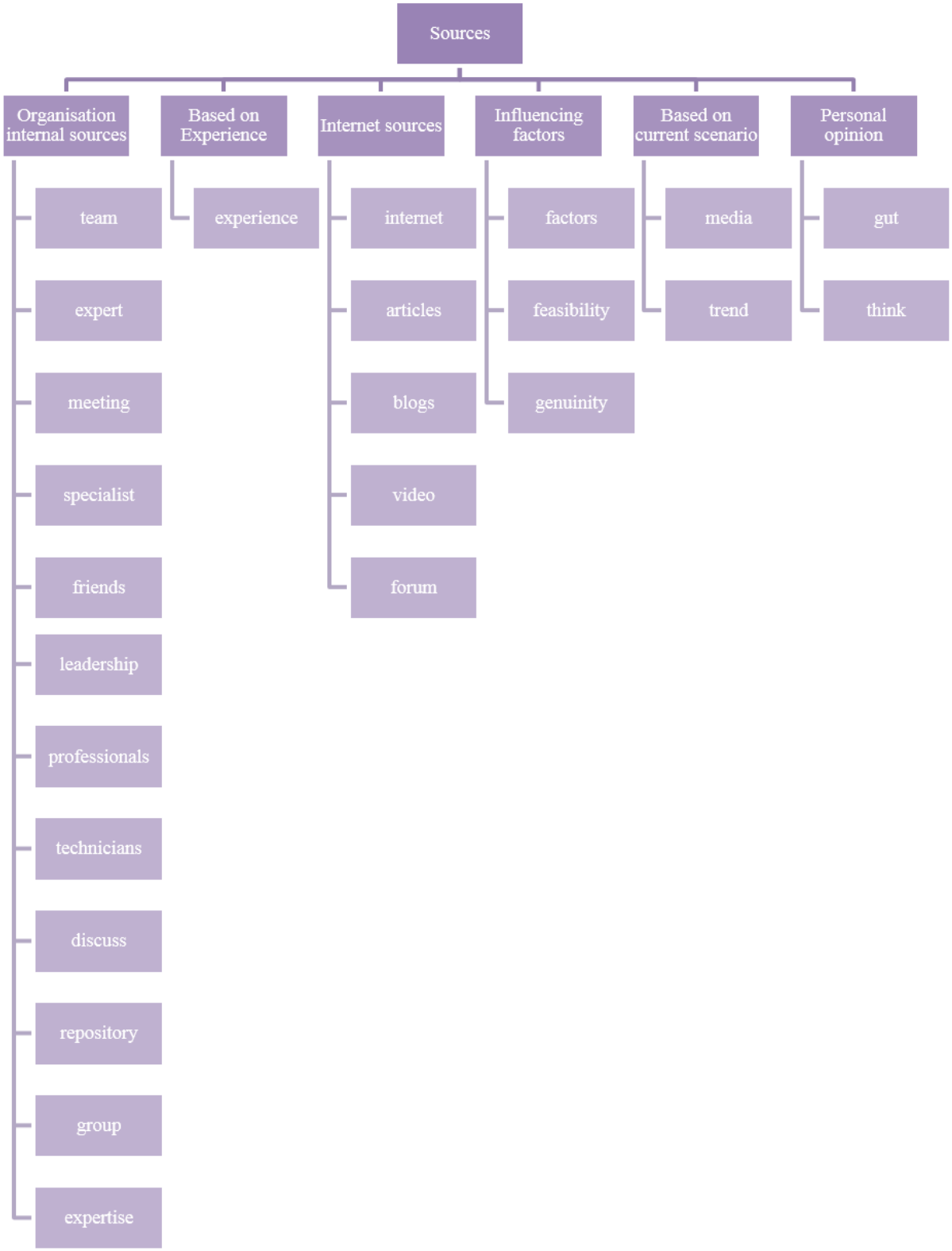







Money
cost
money
profit
benefit
budget
cheap
salary
sales
selling
spend
spent
invest
cheaper
finance
financial
funding
hire
investor
purchasing


Human factors
People
Behavioural patterns
people
person
practitioner
individual
members
decision-makers
mind
behaviour
interested
opinion
perspective
feel
behavior
behave
mindset
perceptions
psychological
satisfaction


Sources
Organisation internal sources
Based on Experience
Internet sources
Influencing factors
Based on current scenario
Personal opinion
team
expert
meeting
specialist
friends
leadership
professionals
technicians
discuss
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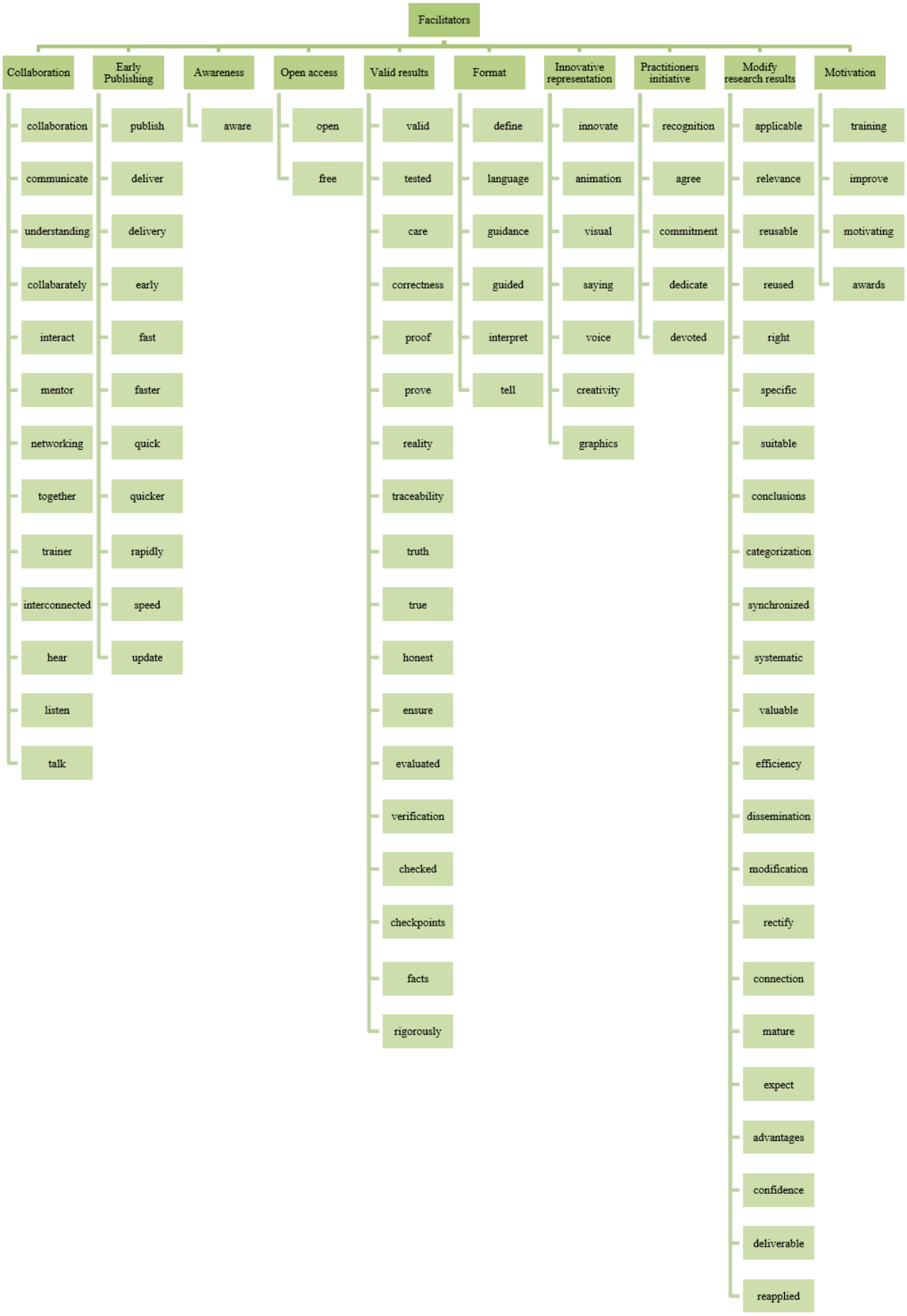
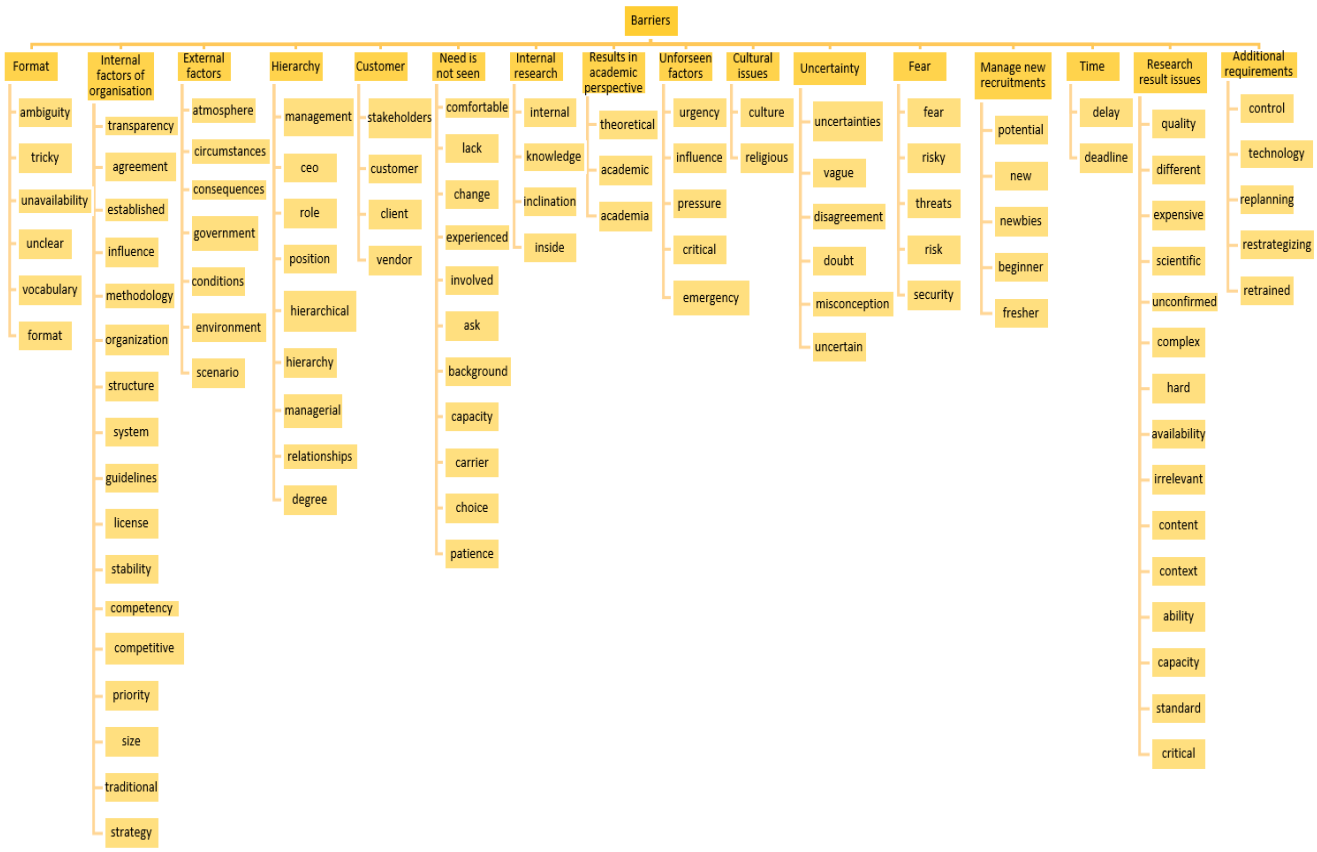
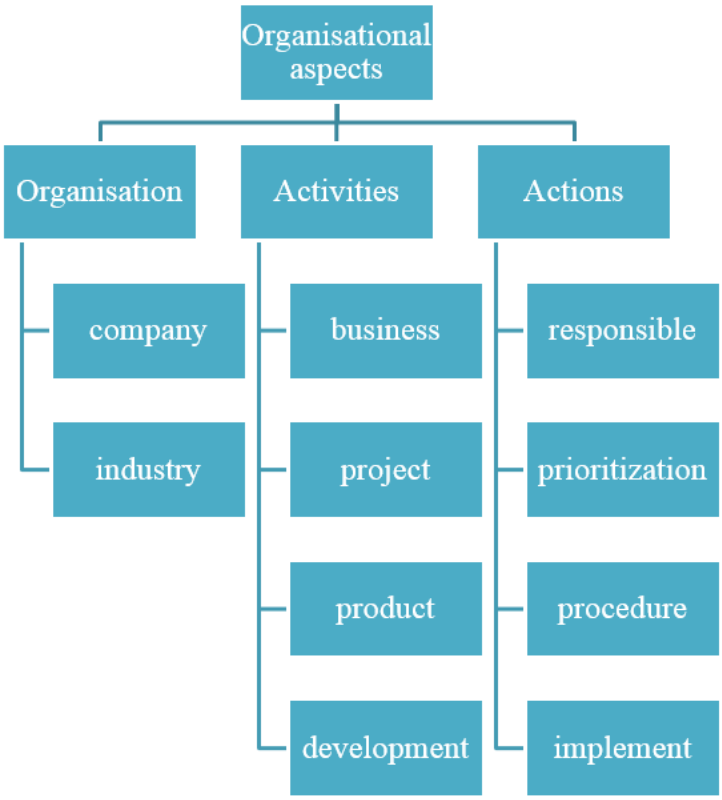
group
expertise
experience
internet
articles
blogs
video
forum
factors
feasibility
genuinity
media
trend
gut
think


Facilitators
Collaboration
collaboration
communicate
understanding
collabarately
interact
mentor
networking
together
trainer
interconnected
hear
listen
talk
Early Publishing
publish
deliver
delivery
early
fast
faster
quick
quicker
rapidly
speed
update
Awareness
aware
Open access
open
free
Valid results
valid
tested
care
correctness
proof
prove
reality
traceability
truth
true
honest
ensure
evaluated
verification
checked
checkpoints
facts
rigorously
Format
define
language
guidance
guided
interpret
tell
Innovative representation
innovate
animation
visual
saying
voice
creativity
graphics
Practitioners initiative
recognition
agree
commitment
dedicate
devoted
Modify research results
applicable
relevance
reusable
reused
right
specific
suitable
conclusions
categorization
synchronized
systematic
valuable
efficiency
dissemination
modification
rectify
connection
mature
expect
advantages
confidence
deliverable
reapplied
Motivation
training
improve
motivating
awards

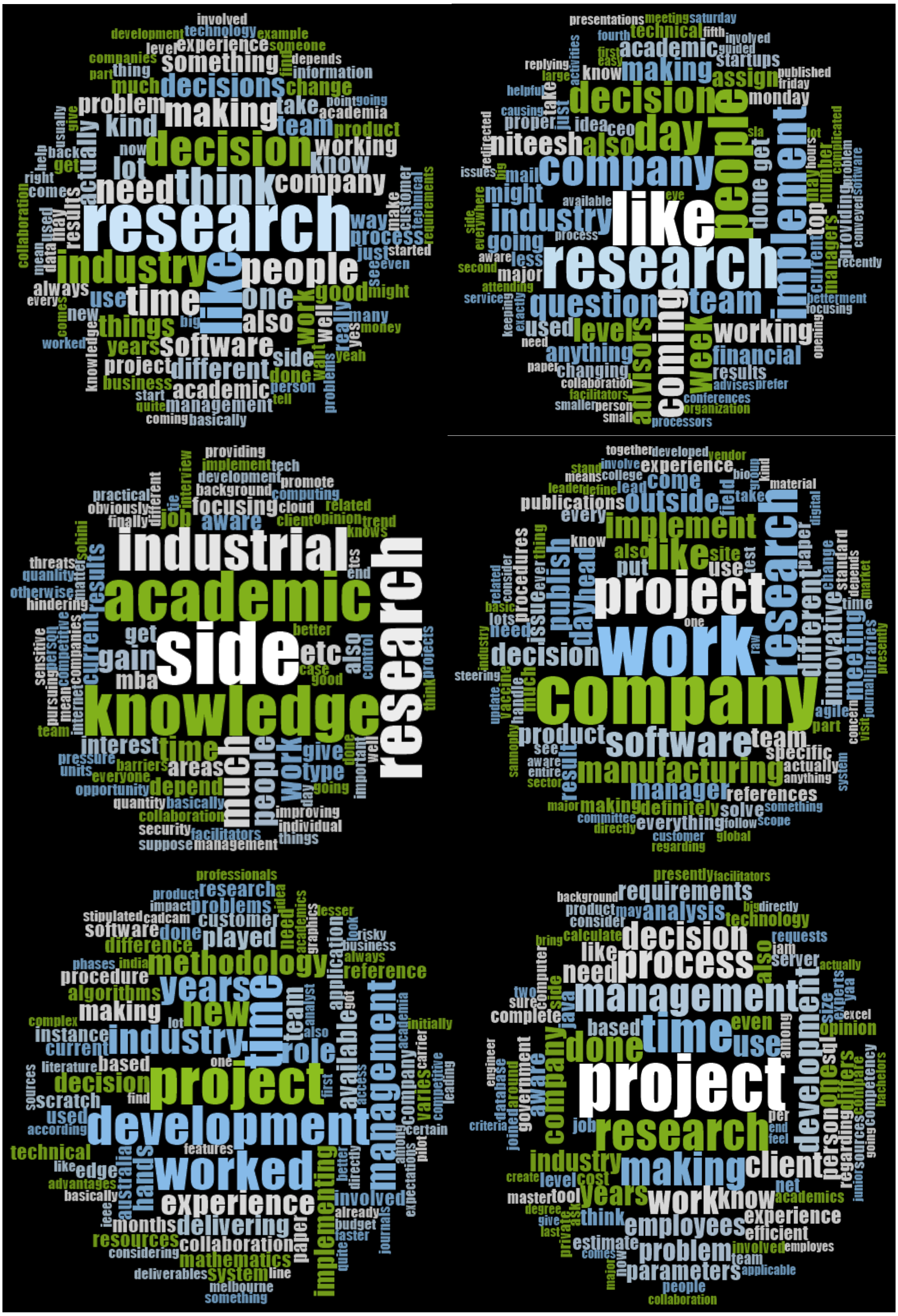

Barriers
Format
ambiguity
tricky
unavailability
unclear
vocabulary
format
Internal factors of organisation
transparency
agreement
established
influence
methodology
organization
structure
system
guidelines
license
stability
competency
competitive
priority
size
traditional
strategy
External factors
atmosphere
circumstances
consequences
government
conditions
environment
scenario
Hierarchy
management
ceo
role
position
hierarchical
hierarchy
managerial
relationships
degree
Customer
stakeholders
customer
client
vendor
Need is not seen
comfortable
lack
change
experienced
involved
ask
background
capacity
carrier
choice
patience
Internal research
internal
knowledge
inclination
inside
Results in academic perspective
theoretical
academic
academia
Unforseen factors
urgency
influence
pressure
critical
emergency
Cultural issues
culture
religious
Uncertainty
uncertainties
vague
disagreement
doubt
misconception
uncertain
Fear
fear
risky
threats
risk
security
Manage new recruitments
potential
new
newbies
beginner
fresher
Time
delay
deadline
Research result issues
quality
different
expensive
scientific
unconfirmed
complex
hard
availability
irrelevant
content
context
ability
capacity
standard
critical
Additional requirements
control
technology
replanning
restrategizing
retrained


Organisational aspects
Organisation
Activities
Actions
company
industry
business
project
product
development
responsible
prioritization
procedure
implement

APPENDIX-I

WORD CLOUD IMAGES FROM NVIVO


change
research
working
propose
people
process
decision
time
something
implement
think
research
academia
lot
like
work
using
different
years
customers
like
things
develop
research
technology
something
know
software
use
just
think
like
research
company
kind
strategy
team
change
side
think
industry
academics
research
example
decision
problem
something
research
like
decision
time
think
industry
people
software
making
need


research
think
decision
making
decisions
industry
like
people
time
need
company
problem
kind
software
something
experience
like
research
people
implement
company
decision
day
industry
question
team
coming
week
academic
making
financial
working
research
side
academic
knowledge
industrial
much
people
work
time
work
company
project
research
implement
outside
software
manufacturing
different
project
development
time
worked
methodology
management
years
industry
new
role
experience
implementing
project
research
management
process
time
decision
making
years
work
client
development
requirements
problem
employees
parameters