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EFFECTS OF ELECTRONIC COMMUNICATION ON THE ELICITATION OF TACIT KNOWLEDGE IN INTERVIEW TECHNIQUES FOR SMALL SOFTWARE DEVELOPMENTS

By

NAUMAN AHMAD

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School of Computing and Engineering

University of Huddersfield, UK

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PUBLICATIONS AND RESEARCH WORK

Ahmad, N., Lu, J. & Dweib, I. 2014. Effects of Podcast as a Communication Tool on the Elicitation of Tacit Knowledge on Interview Techniques for Small Software Developments, *Proceedings of the 2nd International Conference on Applied Information and Communications Technology- 351-357, ICAICT Oman,* Elsevier Publications 2014.

Ahmad, N., Dweib, I., & Lu, J. 2016. Effects of Electronic Communications on Interview Techniques in Requirements Engineering. *Egyptian Computer Science Journal,* 40(1), 84-94.

Ahmad, N., Lu, J., & Dweib, I. 2017. Effects of Electronic Communication Tools as Moderating Variables on Tacit Knowledge Elicitation in Interview Techniques for Small Software Developments. *Journal of Theoretical and Applied Information Technology*, 95(23), 6431-6453.

For each of the three papers, I am the lead author and was the sole PhD student. I carried out all research work and wrote and revised the manuscript with minor changes from my co-authors.

ABSTRACT

Interviewing is an essential practice for the elicitation of requirements, and a significant phase of the system development life cycle that is used for in-depth discussions. However, professionals face difficulties in extracting tacit (hidden) knowledge from interviewees, which disturbs the practice of interviewing, and later, affects the success of software in terms of additional cost, delays, failure or cancellation. In this study, a new approach is introduced using four different modes of electronic communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' (a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session') to discuss the details of interview agenda with interviewees, before conducting semi-structured interviews for the requirements elicitation phase of software development. This research has used a concurrent triangulation design for mixed methods and compared the effects of the four electronic communication tools on the interview process, in relation to tacit knowledge elicitation. The total number of subjects was 120, divided into four equal groups of 30 subjects for 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid'. Two hypotheses were tested through quantitative data collection, to evaluate the effects, and differences in effectiveness among these four electronic tools towards six famous key areas including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', and 'Tacit Knowledge Elicitation', respectively. Grounded theory was used to address the research question through the elicitation of qualitative data, gathered by semi-structured interviews, and the outcomes are visualized through a 'Spider Chart' (a diagrammatic way of presenting multivariate data) towards four key areas of requirements ('General', 'Functionality', 'Usability', and 'Content') for the construction of a website. Prompting was calculated during the interviews, and its percentage is presented through 'Comparison Chart'. There were four steps for each group, concerning this study including (1) Participants' feedback through survey questionnaires before e-tool usage. (2) Use of an e-tool for detailed discussions of interview agenda. (3) Attending the interview (4) Post interview feedback through survey questionnaires after e-tool usage. Analysis has revealed that this research has produced state-of-the-art results. These four electronic communication tools have acted as moderating variables, and affected the process of interviewing positively, towards the elicitation of tacit knowledge, accompanied by a clear difference in the effectiveness of each electronic communication tool. This method can increase the success rate of upcoming software developments.

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First of all, I would like to thank ALLAH, the Almighty for the benedictions and strengths bestowed upon me to complete this thesis.

Many thanks to all of those, involved directly or indirectly for helping me to complete all this.

I dedicate this thesis to:

My parents, wife and daughters (Waniya Nauman, Fatima Nauman and Aamna Nauman).

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CHAPTER 1
INTRODUCTION

Computers have intervened in every part of our life, as banks, planes, security systems, shopping centers, smart phones, factories, and practically everything is centered on these machines. Their success is based on accurate working of their software system. Let us consider, if all the software systems stop functioning, or all the machines are turned off for a minute, what will happen? Certainly, unmanageable disasters would arise because our transactions, travelling, communications, contacts are based on their correct operation.

Experts are developing software and interviewing is a significant method during the practice of development that is mostly used to extract information from interviewees (Malik et al., 2020). However, specialists find difficulties while gathering tacit (hidden) knowledge (Hayek, 1945, Polanyi, 1967; Minrata et al., 2020). Problems to collect tacit knowledge are recognized as weak requirements that interrupt the process of interviewing (Minrata et al., 2020; Expert, 2020). Moreover, weak requirements affect the success of developed software in terms of additional cost, delays, failure or cancellations (Standish, 2016).

Zave (1997) and V3 (2020) defined "Requirements Engineering" as a subdivision of "Software Engineering", relating to functions and limitations of software systems.

Sommerville (2010, 2015) declared five broad requirements of the requirements engineering process, as (a) Elicit (b) Analyze (c) Specify (d) Validate (e) Change/Management. This thesis is concerned with the context of requirements elicitation, one of the important phases of the system development life cycle. Collins (2012) and Cláudio et al., (2015) defined the term 'Elicitation' as a collection of accurate and detailed requirements. Elicitation is centered on single or multiple methods to define the requirements of clients (Hickey & Devis, 2003; Yousuf & Asger, 2015; Malik et al., 2020).

Successful software systems are based on proper elicitation of correct requirements (Dieste, 2008; Mellis et al., 2013; Lenis et al., 2017).

The lack of user input leads to weak requirements that is one of the major factors causing the failure of software (Standish, 2016; Expert, 2020). Poor requirements gathering is a major cause of software failure (Davey & Parker, 2015; Gibbs, 2015). Sumner (2000) claimed weak requirements as a constant reason, leading to failed projects.

Babar, Bunker and Gill (2018) suggested that if elicitation is not done properly, a product will be developed and clients will complain at later stages, consequently, hidden risks would arise to damage performance of a software project.

According to the current and historical data:

- The overall cost of software failure in 2019 for North America was $1.2 trillion that is counted as an overall estimated loss for each year (Undo, 2020).

- The overall estimated amount of poor quality software in the United States of America for 2018 was around $2.84 trillion (Krasner, 2018).

- Financial losses caused by software failures (for 606 projects) in 2017 were $1.7 trillion (Scott, 2018).

- The overall success rate of software projects in 2015 was 29%, however, failed or challenged projects were 71% (Standish, 2016).

- The cost of software failure (for 548 projects) in 2016 was $1.1 trillion (Software, 2016).

- The overall cost of 52.7% software projects were increased to 189% of the real estimation and 31.1% of the projects were cancelled before the stage of completion, however, the rate of success was only 16.2% (Standish, 2014).

- Lindquist (2005) estimated weak requirements as a reason for 71% of the failed projects.

- Communication is a key of software success; conversely, if there are communication gaps then requirements stay incomplete that leads to failure of software (Jakkaew & Hongthong, 2017; Expert, 2020).

- The cost of rectifications done to requirements at a later stage of development process could charge up to two hundred (200) times as compared to the correction at analysis stage (Boehm, 1981).

- Following are eminent elicitation techniques: "Interviewing", "Observation", "Ethnographic Study", "Questionnaire", "Brain Storming", "Protocol Analysis", "Document Analysis", "Laddering", "Prototyping",

"JAD", and "User Scenarios" (Yousuf, Asger, 2015; Malik et al., 2020). The details of these techniques are available in Chapter 2 (section 2.5) of this thesis.

- Interviewing is a common technique of elicitation for detailed collection of requirements that is centered on direct conversation between an interviewer and interviewees (Malik et al., 2020).

During the elicitation, gathering of essential knowledge could be uncertain; consequently, the terms of tacit and explicit knowledge are placed to streamline the difficult areas (Casselman & Samson, 2005; Suryaatmaja et al., 2020). Polanyi (1967) claimed that tacit knowledge is silent due to its difficulty in elicitation. Tacit knowledge is considered as unstated, since it is challenging to quantify as compared to easy communication (Sheposh, 2017).

Tacit knowledge is hidden that should be best shared by the participants (Collins, 2012; Cláudio et al., 2015). Nonaka and Takeuchi (1995) referred tacit knowledge as the possession of information by an individual that contains intangible aspects, such as personal belief and perception. Individuals keep their own vocabularies and terms, therefore, it is difficult for them to find suitable ways and wordings to describe the knowledge (Cláudio et al., 2015).

Specialists face difficulty in elicitation towards the management of tacit and explicit knowledge, therefore, tacit knowledge is the personal belief of an individual, and explicit knowledge is easy to explain (Nonaka & Takeuchi, 1995; Polanyi, 1967).

Tacit knowledge is an insight of a person, such as tricks of business, skills and expertise; however, explicit knowledge is explainable, like written reports, manuals, rules and directions (Reichental, 2006).

The inspiration of this study came from the following:

a). Elicitation of Tacit knowledge is continuously a challenging task for practitioners (Cass, 1998; Hafeez et al., 2014; Suryaatmaja et al., 2020).

b). Researchers have continuous opportunities to suggest different techniques for the elicitation of tacit knowledge, relating to a known problem (Finkelstein, 1994; Avgeriou, et al., 2011; Minrata et al., 2020).

Projects development should be progressed from small to medium and large, since small projects are easy to handle in implementation (Costin, 1980).

Small, medium and large software developments require effective practices of elicitation (Basharat et al., 2013).

Interview is a common technique of elicitation (Malik et al., 2020; Yousuf & Asger, 2015; Mikene, Gaizauskaite, & Valaviciene, 2013). Providing the agenda of an interview is a practice to develop an understanding between interviewer and interviewees (Berg, 2007; Martin & Quan-Haase, 2013). Participants perform collaborations in an effective manner through synchronous and asynchronous communications (Reese, 2015). Synchronous is a real-time communication such as online chat sessions, however, asynchronous communication is based on feasible

schedule such as reading and replying e-mails and listening of audio podcasts (Reese, 2015).

Online interviewing through electronic communication tools is an effective method, however, there is a need of other ways for bridging of understanding gaps between an interviewer and interviewees (Barratt, 2012; Pearce, Thøgersen-Ntoumani & Duda, 2014; Ahmad, Lu, & Dweib, 2017). Therefore, the objectives of this research were to practically evaluate the effects of electronic communications tools for the elicitation of tacit knowledge in interview techniques through the detailed discussions of interview agenda before the process of interviewing. In conclusion, this study was focused on the elicitation phase of software development, to elicit the tacit knowledge that was intended towards the development of a course website, as a small software project.

Following is the motivational summary of this research:

1) There was a huge financial loss in trillions of dollars produced by software failure (Undo, 2020; Krasner, 2018; Scott, 2018). Generally, 71% of the software projects were failed or challenged as a result of weak requirements elicitation (Standish, 2016).

2) Tacit knowledge is essential for companies, since it could be for unlimited benefits, therefore, effective methods should be the part of strategies adopted by companies to be successful (Nonaka & Takeuchi, 1995).

3) Interviewing techniques are common methods for requirements elicitation, therefore, understanding their effects in production of high quality

requirements are extremely important (Spoletini et al., 2018; Ahmad, Lu, & Dweib, 2017).

4) Interview technique is a common practice for elicitation of requirements that is well known by specialists, however, understanding the effects of electronic communication tools will help them to develop improved ideas about the support of these electronic tools for conducting the interviews (Ahmad, Lu, & Dweib, 2017).

5) There are limited studies evaluated the effects of electronic communications on elicitation of tacit knowledge for interview techniques (Abran et al. 2003). Elicitation of tacit knowledge is continually a challenging task (Suryaatmaja et al., 2020). Researchers have continues opportunities to suggest new methods of tacit knowledge elicitation (Minrata et al., 2020). Body of knowledge needs to be enriched with related experiences and skills, if the field of Software Engineering is to be acknowledged by means of an authentic area (V3, 2020).

1.1. Significance and Relevance

North America had paid the cost of $1.2 trillion in 2019 for software failure that is the calculated loss for every year (Undo, 2020). Scott (2018) investigated six hundred and six (606) failed projects in 2017 that had affected 3.6 billion people, time loss of 268 years and financial damage of $ 1.7 trillion that was 10% higher than 2016. Standish (2016) stated the success rate of software projects as 29% in

2015, however, challenged or failed projects were 71%. Software failure had affected 4.4 billion people, and the financial losses in terms of cost were $ 1.1 trillion for 548 investigated projects in 2016 (Software, 2016). Inaccurate elicitation produces weak requirements that is one of the constant reasons for software failure throughout the literature (Davey & Parker, 2015; Gibbs, 2015). If requirements are elicited inaccurately at an initial stage, unpredicted future work needs to be done for invisible problems (Blokdijk, 2015). Weak requirements as a result of imprecise user input is one of the main reasons leading to the failure of software projects (Standish, 2016; Expert 2020). If elicitation is incorrect, the developed project will have complaints that will arise at later stages, consequently, substantial work needs to be done to fix the problems (Babar, Bunker & Gill, 2018).

Understanding perception of users for gathering the correct requirements is one of the major challenges (Standish, 2016; Saiedian & Dale, 2000; Expert, 2020).

Tacit knowledge is non-explicit and elicitation of tacit knowledge is a continuous challenge for analysts (Cass, 1998; Hafeez et al., 2014; Suryaatmaja et al., 2020). There are continuous opportunities to propose diverse techniques for the elicitation of tacit knowledge (Finkelstein, 1994; Avgeriou, et al., 2011; Minrata et al., 2020). Different methods need to be developed for the elicitation phase of requirements engineering (Finkelstein, 1994; Yousuf, Asger, 2015). There is a continuous requirement in research studies related to managing features of software development (Aurum & Wohlin, 2003; V3, 2020).

Polanyi is the pioneer of tacit knowledge (Reichental, 2006). Knowledge can be a combination of suppositions and deductions, hence, knowledge can be collected in

the perspective of a person who knows extra than what can be shared (Polanyi, 1967).

Many software development companies directly concentrate with large projects standing on huge sum with the risks of significant disasters at the end, therefore, go small for project success, since small projects are controllable and outcomes are applicable to medium and large projects (Rosato, 2018). The process of projects development should move from small to medium and large, because small projects are easy to handle and implement (Costin, 1980). There is an immense need of effective elicitation practices for small, medium and large software developments (Basharat et al., 2013).

Incorrect extraction of tacit knowledge produces weak requirements, consequently, fails the software projects (Minrata et al., 2020). Software failure is affecting companies with huge amount of financial losses (Undo, 2020; Krasner, 2018; Scott, 2017). Consequently, exploration of tacit knowledge elicitation towards the formation of improved requirements proves the significance and relevance towards this research activity. Eventually, this research should help and support the development of successful software projects.

1.2. Research Elements

This section defines research question, hypotheses and research design addressed by this thesis.

Electronic mail is easy to use and allows immediate access between sender and receiver (Vdovin, 2020). Audio podcast is beneficial to convey information that

could be saved on smart phones and personal computers to listen to the recorded information at any time (Sansinadi et al., 2020). Online chat session motivates efficient communications and produces innovation (Kashyap, 2020). One of the beneficial use of audio podcast is to send interview questions (Rech, 2007). Text interviews through online chat sessions, e-mail interviews, e-surveying and virtual interviews are useful methods for conducting the electronic interviews (Dickson, Mavis, & Adu, 2020). Therefore, electronic communications tools ('Audio Podcast', 'E-mail', & 'Online Chat Session') are beneficial. However, their usage is only for conducting the interviews and performing general communications. Hence, these benefits of 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid' (a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session') need to be used for the discussions of detailed pre-interview agenda with the interviewees, because it is not a known practice and this gap needs to be filled.

This research was tested using a concurrent triangulation design for mixed methods based on quantitative and qualitative data. Following Tables 1 and 2 demonstrate the hypotheses tested in research for electronic communication tools: 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid' towards six key areas including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', 'Elicitation of Tacit Knowledge'.

Table 1. First hypothesis – testing the effects of electronic communication tools (Ahmad, Dweib, & Lu, 2016).

Friendly: H_0: **There is no effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Friendly'** H_1: **There is a positive effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Friendly'**
Comfortable: H_0: **There is no effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Comfortable'** H_1: **There is a positive effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Comfortable'**
Essential: H_0: **There is no effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Essential'** H_1: **There is a positive effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Essential'**
Understanding: H_0: **There is no effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Understanding' the interview requirements** H_1: **There is a positive effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Understanding' the interview requirements**
Learning: H_0: **There is no effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Learning' the interview requirements** H_1: **There is a positive effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Learning' the interview requirements**
Elicitation of Tacit Knowledge: H_0: **There is no effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Elicitation of Tacit Knowledge' sharing process** H_1: **There is a positive effect of the ('Audio Podcast'/'E-mail'/'Online Chat Session'/'Hybrid') tool usage on the key area 'Elicitation of Tacit Knowledge' sharing process**

Following six key areas were selected for the questionnaire (Appendix C) through detailed review of literature (Naqvi, 2006; Naqvi & Aijaz, 2006; Ahmad, Al-Khanjari, 2016) to receive participants' feedback for testing the effectiveness of electronic communication tools for both the hypotheses.

The e-communication tool ('Audio Podcast', 'E-mail', 'Online Chat Session' or 'Hybrid') is considered as:

      I.   'Friendly' while using

     II.   'Comfortable' while using

   III.   'Essential' part of interview technique

   IV.   Help in 'Understanding' the requirements of interview

     V.   Help in 'Learning' the requirements of interview

   VI.   Help in 'Elicitation of Tacit Knowledge'

- (Note: Initially the research was planned to analyze ten key areas from survey questionnaire (Appendix C) including 'Friendly', 'Comfortable', 'Essential', 'Interviewer only', 'Interviewer with electronic communication', 'Understanding', 'Learning', 'Collection of ideas', 'Organization of ideas', and 'Presentation of ideas'. After the presentation of paper in the conference (Ahmad, Lu, & Dweib, 2014), received feedback and recommendations from the field experts were discussed with supervisory team. As a result, the focus of research was narrowed to six key areas including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', and 'Tacit Knowledge Elicitation' for the survey questionnaire (Appendix C) through semi-structured interviews (Appendix D)).

Second hypothesis, to test the comparisons of significant differences in effectiveness among 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid' towards above mentioned six key areas is demonstrated in Table 2.

Table 2. Second hypothesis – to test the comparisons of significant differences (Ahmad, Lu, & Dweib, 2017).

Friendly: H_0: All the electronic communication groups have equal effectiveness on the average or $\mu1 = \mu2 = \mu3 = \mu4$ for the key area 'friendly' H_1: The mean effectiveness of at least one electronic communication group is significantly different for the key area 'friendly'.
Comfortable: H_0: All the electronic communication groups have equal effectiveness on the average or $\mu1 = \mu2 = \mu3 = \mu4$ for the key area 'comfortable' H_1: The mean effectiveness of at least one electronic communication group is significantly different for the key area 'comfortable'
Essential: H_0: All the electronic communication groups have equal effectiveness on the average or $\mu1 = \mu2 = \mu3 = \mu4$ for the key area 'essential' H_1: The mean effectiveness of at least one electronic communication group is significantly different for the key area 'essential'
Understanding: H_0: All the electronic communication groups have equal effectiveness on the average or $\mu1 = \mu2 = \mu3 = \mu4$ for the key area 'understanding the interview requirements' H_1: The mean effectiveness of at least one electronic communication group is significantly different for the key area 'understanding the interview requirements'
Learning: H_0: All the electronic communication groups have equal effectiveness on the average or $\mu1 = \mu2 = \mu3 = \mu4$ for the key area 'learning the interview requirements' H_1: The mean effectiveness of at least one electronic communication group is significantly different for the key area 'learning the interview requirements'
Elicitation of Tacit Knowledge: H_0: All the electronic communication groups have equal effectiveness on the average or $\mu1 = \mu2 = \mu3 = \mu4$ for the key area 'elicitation of tacit knowledge sharing process' H_1: The mean effectiveness of at least one electronic communication group is significantly different for the key area 'elicitation of tacit knowledge sharing process'

Research Question

Are there any differences among the effectiveness of electronic communication tools including 'Audio Podcast', 'E-mail', 'Online Chat Session',

and 'Hybrid' for the elicitation of tacit knowledge towards the process of interviewing?

Further details of the research question are available in Chapter 3 (section 3.2.2).

Survey questionnaire (Appendix C) was the tool to test both the hypotheses and interview questionnaire (Appendix D) was used for in depth exploration to answer the research question.

1.3. Aim of Research Study

The aim of this research is to assess the outcomes of interview techniques using four electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' [a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session']) on four experimental groups through detailed discussions of pre-interview agenda with the participants for the elicitation of tacit knowledge, intended towards the small software development of a website, using a concurrent triangulation design for mixed methods.

The key objectives of this research are to:

1) Examine the effects of communications tools on the elicitation of tacit knowledge for interview techniques through hypothesis testing towards key areas including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', and 'Tacit Knowledge Elicitation'.

2) Compare the effectiveness among communication tools for the elicitation of tacit knowledge in interview techniques through hypothesis testing towards key

areas including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', and 'Tacit Knowledge Elicitation'.

3) Evaluate the outcomes of interviews towards key areas including 'General', 'Functionality', 'Usability' and 'Content' through semi-structured interviews.

4) Compare the results of prompting through semi-structured interviews.

5) Recommend future work and offer suggestions in the light of research findings.

1.4. Research Design

Figure 1 illustrates the research design as follows (Ahmad, Dweib, & Lu, 2016; Ahmad, Lu, & Dweib, 2017).
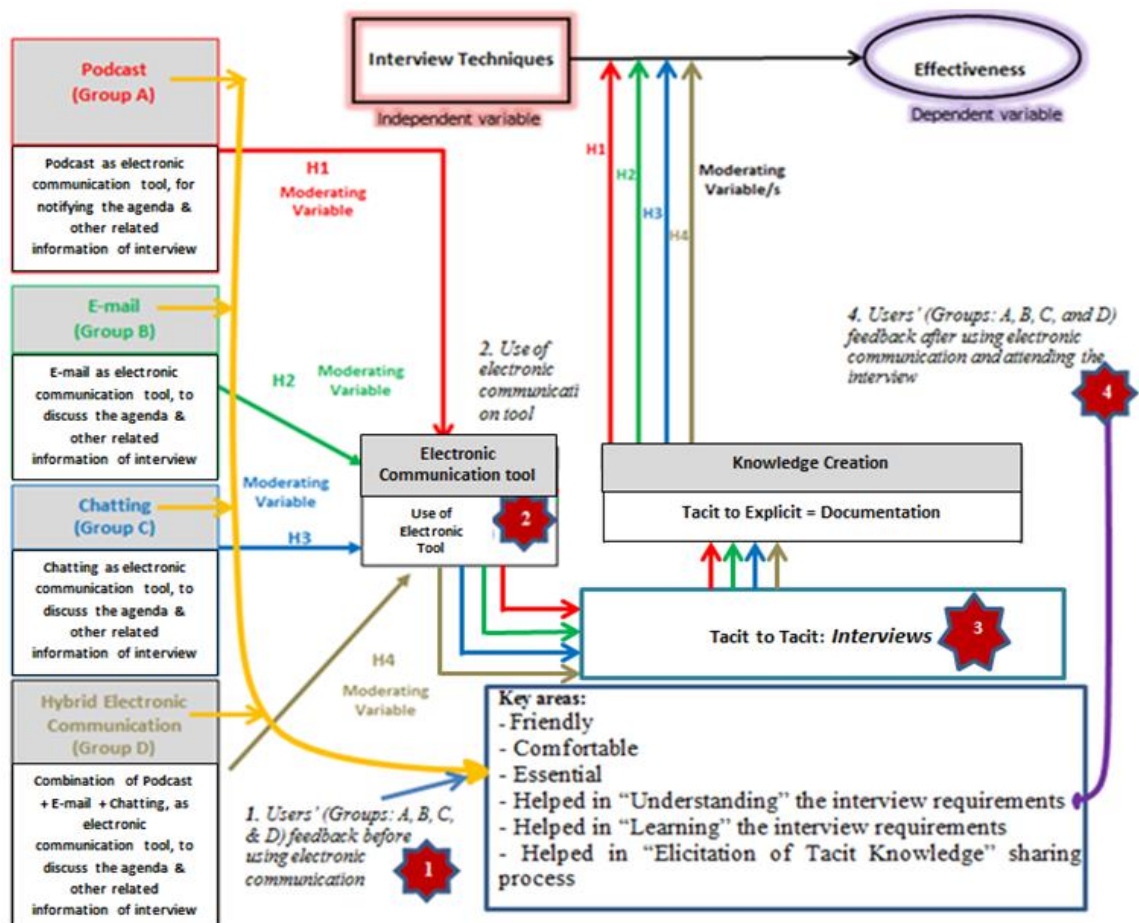
Fig. 1: Four main steps including (1) Participants feedback before e-tool usage. (2) Use of e-tool. (3) Attending the interviews. (4) Post interview feedback of participants about the e-tool usage.

The aim of this research is focused on the elicitation phase of software development through detailed discussions of interview agenda with interviewees (students studying the course), before the process of interviewing for four electronic communications tools including 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' (a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session') with four groups, to test the effects for elicitation of tacit knowledge through a concurrent triangulation design for mixed methods, intended for the development of a course website. Total number of participants was 120, divided into four equal groups of 30 participants. Figure 1 has four steps, including (1) Participants' feedback (through Appendix C – before the use of electronic communication tools) from four groups. (2) Use of electronic communication tools to perform the detailed discussions of agenda before the interview meetings. (3) Attending the semi-structured interviews (Appendix D) for the process of 'tacit to tacit' = interviews and 'tacit to explicit' = documentation. (4) Participants' feedback after the use of electronic communication tools (through Appendix C - after attending the interviews).

1.5. Thesis Organization and Highlights

Following unit informs about the organization of coming parts in the thesis:

In Chapter 2, the review of literature is provided that includes software failures and delays, reasons for failures and delays, software engineering body of knowledge (SWEBOK) and requirements engineering, requirements elicitation, types of knowledge, knowledge transfer and user sharing skills, elicitation

techniques, communications and use of electronic communication tools, and challenges and opportunities in tacit knowledge elicitation.

In Chapter 3, the methodology of the study is discussed to include: a concurrent triangulation design for mixed methods that is centered on four steps defined by Creswell & Plano (2007), including (1) Quantitative data collection, analysis and results. (2) Qualitative data collection, analysis and results. (3) Mixing (the outcomes of quantitative and qualitative data for validation through results). (4) Interpretation (outcomes of quantitative and qualitative data). Particular procedure employed, review of literature, derived hypotheses and research question (first hypothesis, second hypothesis, research question), selected e-communications to be tested, selected research instrument and experiment, data collection, analysis of data, results and conclusion, layouts of results presentation, used resources, reliability, validity and summary.

In Chapter 4, the results of this study are offered, including details of research study, steps for conducting the research, key areas, type of interview, findings, quantitative analysis and results for first hypothesis through t-Test Paired Two Sample for Means that is a statistical method for concluding the mean differences among two sets of observations (Statistics, 2019), quantitative analysis and results for second hypothesis through One Way Anova - Single Factor that is a statistical method to conclude significant differences among the means of two or more groups (ExcelEasy, 2019), overall average of groups, qualitative analysis and results (research question), results comparisons and illustrations through spider chart that

is a diagrammatic way of presenting multivariate data in two-dimensional diagram for three or more quantitative variables (Fusion, 2019), and percentage of prompting for the collected data through interviews.

In Chapter 5, the conclusions and future work are discussed, implications, recommendations, limitations and summary are offered in the light of research outcomes.

1.6.   Descriptions and Terms

Term	Description
Asynchronous mode/ communication	Reading and replying or listening recorded information according to a feasible schedule, like 'E-mails', 'Audio Podcasts' (Reese, 2015).
Audio Podcast	A tool to listen recorded information from a saved audio file (Rech, 2007; Sansinadi et al., 2020)
DVD	An abbreviation of 'Digital Video Disk' that is circular in shape, made of plastic and used to record data, like audio, video and images (Merriam-Webster, n.d.).
E-communication (electronic communication)	An electronic way of communication, like E-mail (Vdovin, 2020) or online chat session (Kashyap, 2020).
e-tool or e-communication tool (Electronic tool or electronic communication tool)	A tool used to communicate electronically, like audio podcasts, e-mails and online chat sessions. (Barratt, 2012; Pearce, Thøgersen-Ntoumani & Duda, 2014)
E-groups or e-communication groups (electronic communication groups)	Groups of participants' using the electronic communication tools, such as 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid'.
Elicitation techniques	Different types of methods to collect requirements from stakeholders (Yousuf & Asger, 2015; Malik et al., 2020).
E-mail Electronic mail	A method to send and receive the information electronically (Vdovin, 2020; Prahl et al., 2015).

Explicit knowledge	A type of knowledge that is easy to explain and describe (Suryaatmaja et al., 2020; Nonaka & Takeuchi, 1995; Polanyi, 1967).
Flash drive	A portable device used to store and transfer data on computer machines (Merriam-Webster, n.d.).
Hybrid communication tool	A combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session'.
Interview or Interviewing	A tool to collect information that is qualitatively rich and worthy in nature (Mikene, Gaizauskaite, & Valaviciene, 2013; Malik et al., 2020).
Interview agenda	Before an interview, information provided to interviewees for reading that helps to make an understanding about the interview meeting (Berg, 2007; Martin & Quan-Haase, 2013)
Online chat session/Online chatting	Real-time electronic communications (Kashyap, 2020; Reese, 2015).
RE (Requirements Engineering)	A subdivision of software engineering that is related to functions and limitations of software systems. (Zave, 1997; V3, 2020).
Requirements elicitation or Elicitation	A major exercise in requirements engineering to extract requirements from clients and stakeholders (V3, 2020; Rowel & Alfeche, 1997).
SWEBOK (Software Engineering Body of Knowledge)	An international standard that has collection of knowledge for the field of software engineering (Faq, 2020).
Synchronous mode/ communication	Real-time communications, like online chat sessions (Reese, 2015).
Tacit knowledge	Personal belief and perception of an individual that is difficult to explain (Nonaka & Takeuchi, 1995; Suryaatmaja et al., 2020).
USB	An abbreviation of 'Universal Serial Bus' that is an interface to connect different external devices with a computer (Merriam-Webster, n.d.).
User sharing skills	The ability of users to share information (FeIIers, 1987; Expert, 2020).

1.7. Contributions of Thesis

The summary of key contributions for this thesis towards the electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid') is as follows:

- A new approach to effectively use the electronic communication tools for the discussions of detailed pre-interview agenda with interviewees towards elicitation of tacit knowledge for the interviews.

- An approach that is friendly and comfortable for interviewees.

Provision of a set of electronic communication tools:

- To develop common vocabulary for the process of interviewing between interviewer and interviewees.

- To understand the interview requirements by the interviewees.

- To learn the interview requirements by the interviewees.

- To improve the existing process of interviewing for tacit knowledge elicitation that reduce the overall post development efforts of reworking; consequently, reduces the time and cost.

- To increase the success rate of upcoming software developments.

- An approach that would positively enrich the body of knowledge in SWEBOK.

- Comparative analysis of four electronic communication tools. Anyone of these could be selected according to the feasibility.

1.8.   Barriers and Issues

The objectives of this research are clear and provide a strong base for the further studies and future work. Overall, there were no barriers and issues related to this study. The subject requirements of the research were relevant, their age was similar, level of expertise in using the computers and web resources was equivalent and the cultural background was same. This research was done in the setting of students studying an Information Technology course, therefore, the response rate was high and subjects were focused towards the research study. If a specific method affects a particular situation, it should impact with the same effects to the situation at other times in the future. It should be recognized that if the same research conducted in different environment may produce different results, such as based on different age groups, and diverse cultural backgrounds. Because, cultural difference impacts the capability of assertiveness that is the expressing competency of an individual to convey the thinking (Niikura, 1999; Lee & Bradley, 2002). Seniority of age supports in better understanding and performance as compared to juniors that is known as relative age effect (Musch & Grondin, 2001; Wattie, Cobley & Baker, 2008). Moreover, age difference is a controlling variable because elder individuals own different level of skills and capabilities as compared to youngers (Johnson, 2005).

1.9.   Summary

This Chapter explains that weak requirements elicitation leads to dissatisfied end users that results in reworking at later stages (Babar, Bunker & Gill, 2018). Weak

requirements are the outcomes of incorrect explanation by users that is one the major problems for software development (Standish, 2016; Expert, 2020). Successful software systems are centered on the proper elicitation of correct requirements (Dieste, 2008; Mellis et al., 2013; Lenis et al., 2017).

Interview is a common technique among different techniques of elicitation (Maiden and Rugg, 1996; Yousuf, Asger, 2015). Interview method is a weaker tool of elicitation (Hart, 1985; Ho, 2006; Malik et al., 2020). Nevertheless, these studies do not prove this claim with experimental evidences. To determine this, specifying the impact of interview method could be verified with a research study that can provide a practical evidence. In addition, effects of electronic communication tools for the detailed discussions of pre-interview agenda are not measured (Ahmad, Lu, & Dweib, 2017).

This study attempts to test the effects of electronic communication tools through the detailed discussions of pre-interview agenda with the interviewees and the elicitation of tacit knowledge through face to face interviews, intended for a small software development.

The literature review recommends that organizations should focus on the elicitation of tacit knowledge from users, because it is one of the major key to produce effective outcomes of projects (Nonaka & Takeuchi, 1995; Lubit, 2001; Ali & Lai, 2017; Xiaodong, 2018).

This research has endeavored to practically explore the effects of interview technique for the elicitation of tacit knowledge through detailed discussions of pre-

interview agenda with the interviewees using electronic communication tools. The concurrent triangulation design for mixed methods was used. Feedback of the subjects was taken through questionnaires (Appendix C) and face to face semi-structured interviews were taken through interview questionnaires (Appendix D).

In summary, the author delivered an inspiration towards the research area, implications of expected outcomes and essential queries for the future work.

CHAPTER 2

LITERATURE REVIEW

2.1. Scope

The aim of this study is to assess the effects of electronic communications on interview technique for the elicitation of tacit knowledge through detailed discussions of pre-interview agenda with the interviewees. Researcher has selected four electronic communication tools including 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' for the detailed discussions of pre-interview agenda with the interview participants.

The scope of this study leads to diversity of research areas. The review of literature uncovers the boundaries and limitations of available research that is a rich source of motivation towards the research area.

2.2. Software Failures and Delays

Computers are everywhere, as banks, communications, security systems, shopping centers, smart phones, factories, planes, and nearly everything is centered on these machines and accurate working of software system is the key of their success (Ahmad, Lu, & Dweib, 2017).

Lime, a transportation-rental company, found errors in the software of their electric scooters by stiff application of brakes and sudden lock of wheels, consequently, these errors had damaged the collarbones and jaws of users and the company had removed full fleet of the scooters in 2019 (Roy, 2019).

Wessex Regional Information Systems Plan (RISP) was a software for Regional Health Authority of Wessex, England that was developed in 1990 and failed with a cost of $64.5 million (Kopec, 2000).

'Taurus' (Transfer and Automated Registration of Uncertificated Stock) was a software, started in 1983 for London Stock Exchange and failed in 1993 with a cost of £400M, because of weak requirements (Catalogue, 1993).

'Bolit' was a financial management software for customers that was implemented by 'Patent and Registration' office of Sweden in 1997 and failed with an additional cost of $35M (Kienitz, 2017).

Home office of UK had cancelled the contract of 'e-Borders' software in 2010. The software development was intended for immigration control system, however, issues in requirements understanding had caused the mismatching of milestones, ensuing a cost of £830M (Alami, 2016).

ITGS (2012) reported about Expeditionary Combat Support System (ECSS), an IT project of US air force, aimed to enhance communications and logistic operations. This project was cancelled in 2012 after an investment of $ 1 billion; alternatively, an additional amount of $ 1 billion was required to rework on the requirements, to attain projected functioning of 25 percent in 2020.

Central govt. of Canada had started a project to place 1500 websites in one portal; nevertheless, 10,000 web pages were shifted in three years and an additional cost of $28M was granted to the project (Kienitz, 2017).

'POLSAG' was an IT based police case management system, intended to develop for Danish national police, however, the project was cancelled with a loss of $70M in 2012, because of the lengthy and costly process (POLSAG, 2013). BBC digital media initiative project was failed with a loss of £98.4M (Conlan, 2013). Successful software projects in 2015 were 29%, however, failed or challenged were 71% (Standish, 2016). Software (2016) had investigated five hundred and forty eight (548) failed software projects in 2016; consequently, 4.4 billion people were affected with a financial loss of $1.1 trillion.

Scott (2018) investigated six hundred and six (606) failed software projects in 2017 that had affected 3.6 billion people. The projected loss of time was 268 years, with an estimated loss of $1.7 trillion. Moreover, total number of stated software failures in 2017 were 10% higher than 2016.

2.2.1. Reasons for Software Failure and Delays

Elicitation of weak requirements is one of the major reasons of software failure, because users cannot explain their ideas properly; therefore, an appropriate way of communication is the solution of this issue (Expert, 2020).

When requirements are not collected properly, the outcomes are poor requirements that is a constant reason of software failure throughout the literature (Davey & Parker, 2015; Gibbs, 2015).

Understanding the perception of users for gathering the correct requirements is a major challenge during the process of requirements engineering (Standish, 2016; Saiedian & Dale, 2000). Elicitation of weak requirements in software development

is recognized as 71% of projects failure; therefore, it is one the major reasons leading to unmatched targets (Lindquist, 2005).

Blokdijk (2015) remarked that if the requirements are not elicited properly at the initial stages, unexpected future work needs to be done for unseen problems.

Lack of users' contribution produces weak requirements, consequently, rate of software success is only 29% (Standish, 2016).

If the process of elicitation is weak then the client may have complaints at later stages, consequently, plenty of rework needs to be done that can damagingly effect the performance of software (Babar, Bunker, Gill, 2018).

2.3. Software Engineering Body of Knowledge (SWEBOK) and Requirements Engineering

In order to consider software engineering as an authentic field of engineering, IEEE computer society had started the collection process of body of knowledge in 1990 and disseminated as a guide, termed as SWEBOK (Software Engineering Body of Knowledge), an international standard that is a collection of knowledge for the field of software engineering (Faq, 2020). Professionals from different fields had worked together for the preparation of the guide to acknowledge the body of knowledge; consequently, the current version of SWEBOK is V3 with 15 knowledge areas of software engineering that starts from software requirements, design, construction, testing, maintenance, computing, and ends at mathematical and engineering foundation (V3, 2020). Software requirements is the first knowledge area of software engineering that is a significant phase in system development life cycle

(SDLC), because it works with the formation of requirements from stakeholders and has following activities for the software requirements (V3, 2020):

- Elicitation

- Analysis

- Specification

- Validation

- Management/Change

The activity of requirements elicitation in the knowledge area of software requirements is done through requirements engineering (V3, 2020).

SWEBOK evolution team and IEEE computer society are operational on designing the detailed architecture, intended for the next evolutionary version that would be accessible as public wiki in next coming years (Evolution, 2020).

Requirements engineering is a subdivision of software engineering (Zave, 1997; V3, 2020). Requirements engineering is a method to describe, document and maintain the requirements in software engineering (Nuseibeh & Easterbrook, 2000; V3, 2020).

Requirements engineering is a major segment in software engineering that elicits and communicates with users, however, failure in communications leads to inaccurate requirements (Jakkaew & Hongthong, 2017). Software requirements are the depiction and limitation of the system services, produced during the process of requirements engineering (Sommerville, 2015).

Following are the stages of requirements engineering (Sommerville, 2010; Sommerville, 2015):

- Elicitation

- Analysis

- Specification

- Validation

- Change/Management

SWEBOK had updated its version from 'SWEBOK 2004' to 'SWEBOK V3', because it endeavors to revise the old version with new books and articles supplemented to body of knowledge (V3, 2020). SWEBOK is developing a public wiki of updated knowledge (Evolution, 2020). Therefore, there is a frequent need of improvement in the body of knowledge and next revision waits for it.

Table 3 summarizes the literature on software failures and delays, reasons for software failures and delays, SWEBOK and requirements engineering.

Table 3. Software failures and delays, reasons, SWEBOK and requirements engineering

Literature	Reference
Lime, a transportation-rental company, found faulty software in their electric scooters, causing severe injuries to the users, consequently, company had removed its full fleet.	(Roy, 2019)
Wessex Regional Information Systems Plan (RISP) was failed in 1990 with a loss of around $64.5 million.	(Kopec, 2000)
Taurus, a software project developed for the London Stock Exchange in 1993 was failed with a loss of £75M.	(Catalogue, 1993)
'Bolit' was a software system implemented by the 'Patient and Registration' office of Sweden in 1997 that was failed with an additional cost of $35M.	(Kienitz, 2017)

'e-Borders' a software for Home office of UK was cancelled in 2010 due to mismatching of milestones that had a financial loss of £830M.	(Alami, 2016)
The Expeditionary Combat Support System (ECSS) for the US air force was scrapped in 2012 after an investment of $1 billion. It required an additional cost of $1 billion to bring it in working condition to 25 percent only, in 2020.	(ITGS, 2012)
The central government of Canada had implemented a website project in 2013 that had an additional cost of $9.4M with an accumulation of $28M, and still continuing.	(ITGS, 2012)
POLSAG, an IT system for police case management of Danish National Police was stopped in 2012, because of non-satisfactory outcomes claiming a cost of around $70M.	(POLSAG, 2013)
BBC Digital Media Initiative project was failed with a loss of £98.4M.	(Conlan, 2013)
Users' deficiency towards in-depth description of their needs produces poor requirements and results in software failure. The solution is appropriate way of communication.	(Expert, 2020)
Overall success rate of software projects in 2015 was 29% and failed or challenged were 71%.	(Standish, 2016)
In 2016, out of 548 failed software projects, the affected number of people was 4.4 billion, with a loss of $1.1 trillion.	(Software, 2016)
In 2017, 606 software failures affected 3.6 billion persons. An estimated lost-time was around 268 years, with a financial loss of $.17 trillion. Moreover, software failures in 2017 were 10% higher than 2016.	(Scott, 2018)
When requirements are not collected properly, the outcome is software failure.	(Davey & Parker, 2015; Gibbs, 2015)
Understanding perceptions of users for gathering the correct requirements is a major challenge.	(Standish, 2016; Saiedian & Dale, 2000; Expert, 2020)
Weak requirements during the process of software development is recognized as 71% of the project failure.	(Lindquist, 2005)

Software Engineering Body of Knowledge (SWEBOK) is an international standard of knowledge collection for software engineering.	(Faq, 2020)
The SWEBOK team in coordination with IEEE is working on the next evolutionary version, as a public wiki.	(Evolution, 2020)
Activities of software requirements and requirements engineering are: 'Elicitation', 'Analysis', 'Specification', 'Validation', and 'Management/Change'.	(V3, 2020; Sommerville, 2010; Sommerville, 2015)
Requirements elicitation for software requirements is done through requirements engineering.	(V3, 2020)
Requirements engineering is a subdivision of software engineering.	(Zave, 1997; V3, 2020)
Requirements engineering is a method to describe, document and maintain the requirements in software engineering.	(Nuseibeh & Easterbrook, 2000); Jakkaew & Hongthong, 2017)
System requirements are representations and limitations of system services formed in requirements engineering.	(Sommerville, 2015)

2.4. Requirements Elicitation

Requirements elicitation is a major exercise in requirements engineering to extract the requirements from clients and stakeholders (Rowel & Alfeche, 1997; Swebokwiki, 2015).

Fellers (1987) offered a model of knowledge engineering with 'knowledge acquisition' as the first part of requirements elicitation process. Elicitation is collection of accurate and detailed requirements from users of the system. In addition, tacit is hidden knowledge that is the key of success for projects, therefore, it should be shared accurately (Collins, 2012; Cláudio et al., 2015; Suryaatmaja et al., 2020).

Elicitation is a practice of gathering the requirements that is a key phase of requirements engineering (Dias et al., 2017; Suryaatmaja et al., 2020). Requirements elicitation is a critical factor of success for the software projects (Lenis et al., 2017). Requirements should be precise and comprehensive for the success of projects (Wiegers, & Beatty, 2013; Suryaatmaja et al., 2020). Elicitation is a major area during the phase of knowledge transfer (O'De11 & Grayson, 1998). Requirements are necessary for the following primary reasons (Maiden & Rugg, 1996):

- To offer the information for development of a solution
- To offer the information for buying a solution

Challenges towards the process of elicitation are as follows (Christel & Kang, 1992):

Difficulty of scope: when the border of system is unclear or clients identify needless information that complicates the things instead of simplifying.

Difficulty of understanding: the clients are clear about the required information, however, do not have a clear idea about the problem, have communication issues in conveying the information, skip the required information that is counted as obvious and identify the requirements that are unsure.

Difficulty of volatility: the requirements vary with passage of time. The degree of variation is occasionally mentioned as scale of volatility.

2.4.1. Types of Knowledge

Knowledge is defined as known details attained through experience, involvement or practice (Collins, 2012; Cláudio et al., 2015). Gathering of knowledge is a continuous process during the phase of elicitation that can be clear or unclear, therefore, it is divided as follows (Casselman & Samson, 2005; Suryaatmaja et al., 2020):

- Tacit knowledge (hidden knowledge)
- Explicit knowledge (knowledge that is easily describable)

'Tacit' and 'explicit' are two terms to streamline the complex areas of knowledge (Casselman & Samson, 2005).

Tacit knowledge is perception of a person, however, 'explicit knowledge' is easily explainable (Nonaka & Takeuchi, 1995; Polanyi, 1967; Suryaatmaja et al., 2020). Machines are worthy sources of 'Explicit' knowledge, however, people are the effective sources of 'Tacit' knowledge (Cláudio et al., 2015). The ability of a person to hold knowledge is more than what can shared (Collins, 2012). Individuals have their personal vocabularies and do not find a suitable approach to share tacit knowledge (Cláudio et al., 2015).

Understanding the perception of users towards the gathering of correct requirements is a major challenge during the process of requirements engineering (Standish, 2016; Saiedian & Dale, 2000; Expert, 2020). If requirements are not elicited properly at initial stage, unexpected future work needs to be done for unseen problems (Blokdijk, 2015). Lack of user input is one of the leading factors,

contributing to failure of software projects; consequently, average rate of success is 29% (Standish, 2016).

2.4.2. Knowledge Transfer

Knowledge transfer is a process of shifting the information to resolve the problems (OECD, 1996).

Knowledge exists in the personnel, tools and subsystems of hierarchical structure in organizations (Argote & Ingram, 2000). Personnel in most companies contain the tacit knowledge that is difficult to extract (Nonaka, & Takeuchi, 1995).

Transfer of knowledge is a process when one division of an organization receives an impact through knowledge and understanding of others that can be detected through variation in knowledge, as follows (Argote & Ingram, 2000):

1). Personalization: belongs to one on one transfer, such as from one individual or unit to another, like how to do cycling.

2). Codification: belongs to the task of changing knowledge into knowledge items, such as metaphors, audios, videos and booklets, those can be used by the receivers in asynchronous manner.

Personalization is a beneficial practice related to an individual holding the tacit knowledge, conversely, codification is used to transfer the knowledge to a huge number of receivers (Sudhindra, Ganesh & Arshinder, 2017).

2.4.3. User Sharing Skills

Fundamental focus of available literature is on the skills and roles of requirements engineers (Groeneveld et al., 2020; Assyne, 2020). Indeed, these two areas are substantial. However, future work is required for the elicitation of tacit knowledge, through the enhancement of user sharing skills, towards the bridging of understanding gaps between interviewers and interviewees (Ahmad, Lu, & Dweib, 2017).

Weaknesses in sharing skills of users produce weak requirements that is one of the key causes, leading to the failure of software, because users have deficiency in detailed explanation of the needs and unable to describe the ideas properly (Expert, 2020).

User-familiarization and ways of communication are user sharing skills, counted as more significant than technical expertise (FeIIers, 1987). Stakeholders need to communicate through diverse ways to escape the problems (Brooks, 1995). Communication is a focal point of elicitation, because communications among stakeholders happen face to face, therefore, a shared vocabulary is required to make the elicitation successful (HoltzbIatt & Beyer, 1995).

Grunbacher and Briggs (2001) proposed a technique to handle two shortcomings faced in requirements engineering: (a) Participants, those are incapable of communicating the correct supplies of information could present an incomplete image. (b) Tacit knowledge clashes with the required information and turns to expensive problems that affects the future of the project; nevertheless, the technique

was unable to develop a common vocabulary to reduce the gaps of understanding between the interviewers and interviewees.

Ascaniis et al. (2017) stated that elicitation of requirements is a significant phase of software development where requirements engineers are expected to elicit maximum and precise outcomes from users through active listening and communications, however, currently, there is no organized training technique towards the development of "User Requirements Elicitation" skills. Researchers had used a simulator to collaborate between users and a game that was centered on narration and interactive model. Simulator enhanced the skills of users and users improved the skills of simulator. Training sessions were required to understand the technology. However, a game cannot be the replacement of human intelligence in responding and clarifying ambiguities, therefore, gaps of understanding between the users and system engineers were not filled.

 Ali and Lai (2017) offered a technique of Global Software Development (GSD) to elicit requirements through enhancing the skills of users with four stages, as follows: (1) Data gathering. (2) Stakeholders' training towards the GSD issues. (3) Post training assessment. (4) Requirements elicitation and its analysis. However, the requirements of training for stakeholders on GSD issues and the time consuming procedure of post training assessments were the barriers of GSD technique. Consequently, common goals of understanding between requirements engineers and the users were neglected.

Hafeez, Farhan and Khan (2017) proposed an enhanced version of an existing model by Nathan W. Mogk for the collection and management of requirements. The model had suggested to contact users in case of any conflict. However, there was no discussion for the reduction of understanding gaps between the requirements engineers and users through the enhancement of user sharing skills towards a common goal.

Fatima et al. (2017) merged Felder-Silverman style models [LSM] with cognitive psychology, for the enhancement of users sharing skills towards the elicitation of tacit knowledge that resulted in improvements. It was centered on four areas of learning in relation to human character: – Active or Reflective, - Visual or Verbal, - Sensing or Intuitive, - Sequential or Global. Proposed model was working on learning styles of human characters, consequently, identification of these four areas was challenging towards the extraction of tacit knowledge.

Spoletini et al. (2018) introduced a technique of review the interview towards enhancement of tacit knowledge elicitation. They claimed that uncertainties of recognized elicitation could be reused by the requirement engineers to ask further questions to extract tacit knowledge. Ambiguities are difficult to identify during the process of elicitation through interviews, because different people understand the ambiguities in different ways. Therefore, exclusive perception of interviewers is insufficient to recognize all the doubts to decrease the count of ambiguities identified in the interviews. A standard was followed to perform the interviews through recordings and reviewing of recorded interviews to detect ambiguities

with the help of reviewers for re-interviews. Sixty eight percent of the ambiguities were revealed through reviewing, however, 32 percent was discovered through the interviewing. The outcomes informed that there was a huge difference of recognition in ambiguity detection between the requirements engineers and the reviewers. Re-interviewing was done with the same stakeholders with follow-up questions, therefore, the ability of stakeholders in sharing the knowledge was at the same level, since their vocabulary and terminologies were same. This technique of review the interview was unable to fill the gaps of understanding towards the common goal of interviewing. Cláudio et al. (2015) claimed that individuals have their own vocabularies and unable to find a suitable way to share tacit knowledge.

Table 4 summarizes the literature on Requirements Elicitation, Types of Knowledge, Knowledge Transfer and User Sharing Skills

Table 4. RE, knowledge types, transfer of knowledge & user sharing skills

Literature	Reference
Requirements elicitation is a major exercise in requirements engineering to extract the requirements.	(Rowel & Alfeche, 1997, Fellers 1987, Dias et al., 2017)
Elicitation is collection of accurate and detailed requirements from users that is a critical success factor of projects.	(O'De11 & Grayson, 1998; Collins, 2012; Cláudio et al., 2015; Lenis et al., 2017)
Weak requirements gathering because of the difficulty in user sharing skills is a main reason for software failure.	(Expert, 2020)
Requirements should be specific and detailed for complete success.	(Wiegers, & Beatty, 2013)
Requirements are necessary to develop or buying a solution.	(Maiden & Rugg, 1996)
Difficulty of scope, understanding and volatility are challenges towards the process of elicitation.	(Christel & Kang, 1992)

Knowledge is the known information achieved through experience or involvement.	(Collins, 2012; Cláudio et al., 2015)
'Explicit' and 'Tacit' are two types of knowledge in the practice of elicitation.	(Casselman & Samson, 2005)
'Tacit' knowledge is the personal belief of an individual, however, 'Explicit' knowledge is easily describable.	(Nonaka & Takeuchi, 1995; Polanyi, 1967)
Machines are best sources of Explicit knowledge, however, people contain the tacit knowledge. People have their own terminologies and unable to find a suitable way to share their tacit knowledge.	(Cláudio et al., 2015)
An individual has more capacity to tell what can be shared.	(Collins, 2012)
Understanding the perceptions of users for the elicitation of correct requirements is a major challenge.	(Standish, 2016; Saiedian & Dale, 2000)
If the requirements are elicited incorrectly, unpredicted work is required to complete the unseen issues.	(Blokdijk, 2015)
Knowledge transfer is a process of shifting information to resolve problems.	(OECD, 1996)
Tacit knowledge exists within the personnel of companies that is difficult to extract.	(Nonaka, Takeuchi, 1995)
Knowledge can be found in the employees of an organization and 'Personalization' and 'Codification' are two divisions of knowledge.	(Argote & Ingram, 2000)
Personalization is a practice to elicit tacit knowledge, and codification is the transfer of knowledge to a huge number of receivers.	(Sudhindra, Ganesh & Arshinder, 2017)
User-familiarization and ways to communicate are user sharing skills that are more significant for elicitation than technical expertise.	(FeIIers, 1987)
All stakeholders need to communicate through different ways to escape from the problems.	(Brooks, 1995)
Communication is the focal point of elicitation, and shared vocabulary needs to be developed for successful elicitation.	(HoltzbIatt and Beyer, 1995)
Easy-Win-Win technique was used to control the following shortcomings: (i) Participants are incapable to communicate with correct information. (ii) Tacit knowledge clashes with the required information.	(Grunbacher & Briggs, 2001)
A simulator was used to collaborate with users, centered on narration and interactive model. However, training sessions were required to understand the technology. Simulator was unable to replace the	(Ascaniis, et al., 2017)

human intelligence, therefore, understanding gaps for participants towards a specific goal remained there.	
A proposed method of Global Software Development (GSD) towards the elicitation of requirements was used with four stages – Data collection, - Stakeholders' training, - Post training assessment, - RE and its analysis. However, the process was time consuming and unable to bridge the gaps of understanding.	(Ali & Lai, 2017)
A new model (an improved version of Nathan W Mogk's model) was used for the collection and management of requirements. Researchers had suggested to contact the users, if conflicts arise. However, understanding gaps between participants and interviewers were unfilled.	(Hafeez, Farhan, & Khan, 2017)
A model proposed by researchers through the merging of Felder-Silverman style models [LSM] and cognitive psychology for the requirements elicitation. However, understanding gaps were unfilled.	(Fatima et al., 2017)
A method was proposed through reviewing the interviews. Nevertheless, understanding gaps between interviewers and interviewees were unfilled.	(Spoletini et al., 2018)

2.5. Elicitation Techniques

There are different types of methods used by specialists for the collection of project related requirements from stakeholders, called elicitation techniques (Malik et al., 2020; Yousuf & Asger, 2015).

Following are details of famous elicitation techniques:

Interviewing: is a famous technique of elicitation based on direct conversations between interviewers and interviewees towards the detailed gathering of requirements (Malik et al., 2020; Yousuf & Asger, 2015; Mikene, Gaizauskaite, & Valaviciene, 2013).

Observation: is identified as social exploration, including vigilant observation of the activities and engagements of a user and documenting the observations (Malik et al., 2020; Yousuf & Asger, 2015; Maalej & Thurimella, 2013; Elisabeth & Krawitt, 2015).

Ethnographic Study: is a collection of cultural information, social occurrences through interviews, observations and questionnaires feedback (Malik et al., 2020; Yousuf & Asger, 2015).

Questionnaire: is equally called a survey that is an economical way of elicitation, since a huge number of respondents can be requested for the feedback (Malik et al., 2020; Yousuf & Asger, 2015).

Brain Storming: is a group based technique of elicitation to collect the ideas from stake holders through group discussions (Malik et al., 2020; Yousuf & Asger, 2015; Junnan & Haibin, 2015).

Protocol Analysis: is a spoken explanation of thinking process from the respondents, those perform the tasks through loud thinking (Malik et al., 2020; Yousuf & Asger, 2015).

Document Analysis: is a technique of studying the existing documents towards the discovery of information that can help the process of elicitation in an efficient manner (Malik et al., 2020; Yousuf & Asger, 2015).

Laddering: is an interviewing technique that uses probes for the process of elicitation, to explore the concepts of interviewees (Malik et al., 2020; Yousuf & Asger, 2015).

Prototyping: is a technique of releasing an early sample of a product (dummy) that furnishes the feedback from end users (Malik et al., 2020; Yousuf & Asger, 2015).

JAD: stands for 'Joint Application Development' that is a workshop activity, based on stakeholders communications, moving jointly towards the outcomes (Malik et al., 2020; Yousuf & Asger, 2015).

User Scenario: is a technique of users' observation while working with the systems (Malik et al., 2020; Yousuf & Asger, 2015).

2.5.1. Interview Technique for Elicitation

Throughout the literature, interview technique is quoted as a famous method to elicit requirements (Purvis & Sumbammurty, 1997; Mikene, Gaizauskaite, & Valaviciene, 2013; Yousuf & Asger, 2015; Trevor, Uta & Eva, 2016; Diane et al., 2018; Malik et al., 2020). In addition, interview is a technique that is supportive in visualization and visual representation (Trevor, Uta & Eva, 2016). Interviewing is a simple method of understanding and communication (Yousuf & Asger, 2015). Interview is a tool to collect the data that is qualitatively rich and worthy in nature (Mikene, Gaizauskaite, & Valaviciene, 2013). Interview is a known method because of its simplicity and familiarity with everyone (Agarwal & Taniru, 1990). Interviewing is a tool that helps in elicitation of unpredicted data from the participants (Liou, 1992). Interview provides an extensive opportunity for gathering detailed information (Fellers, 1987).

2.5.2. Limitations on Interviewing Method

Interview is a weaker tool, because of additional efforts and excessive time used for the extraction of requirements that could affect the outcomes (Hart, 1985; Ho, 2006; Malik et al., 2020). Hart (1985) and Ho (2006) added supplementary reasons for the weakness of interview method, such as: (a) requirements engineers could be exhausted because of continuous repetition to explain different themes and participants may drop the level of interest, consequently, incomprehensible communications result in self-interruptions, alterations, resumptions and telling narrations that could skip the important information. (b) Use of domain based technical jargons leads to understanding gaps between the interviewers and interviewees, hence, the practice of interviewing become extensive and complicated. Therefore, the literature explains that interviewing method is as a weaker tool for the elicitation of tacit knowledge, however, these studies are unable to verify this claim with experimental proofs. To determine this, specifying the impact of the interview method could be verified with a research study to provide the practical evidence. Moreover, effects of other factors, like electronic communication tools for the discussion of interview agenda are unintegrated with interview technique (Ahmad, Lu, & Dweib, 2017).

Table 5 summarizes the elicitation techniques, reasons of interviewing as a famous tool of elicitation, and limitations of interviewing

Table 5. RE techniques, interviewing as a famous tool, and its limitations

Literature	Reference
Interviewing is a famous technique of elicitation for the detailed gathering of requirements.	(Malik et al., 2020; Yousuf & Asger, 2015; Mikene, Gaizauskaite, & Valaviciene, 2013)
Elicitation techniques are as follows: observation, ethnographic study, questionnaire, brain storming, protocol analysis, document analysis, laddering, prototyping, JAD, and user scenarios.	(Malik et al., 2020; Yousuf & Asger, 2015)
Reasons of interviewing as a famous tool of elicitation: - Visualization and visual representation. - Simplicity in understanding and ease of communication. - Rich qualitative data. - Simplicity and familiarity with everyone. - Elicitation of unpredicted data. - Provides an extensive opportunity for the detailed information gathering.	(Trevor, Uta & Eva, 2016) (Yousuf & Asger, 2015) (Mikene, Gaizauskaite, & Valaviciene, 2013) Agarwal & Taniru, 1990 Liou, 1992 Fellers, 1987
Many limiting factors may affect the outcomes of interviewing technique and makes it a weaker tool.	(Hart, 1985; Ho, 2006; Malik et al., 2020)

2.6. Communications

Requirements elicitation is a process of communications for requirements engineers and analysts to communicate with stakeholders (Yousuf & Asger, 2015). Communications with stakeholders through different ways minimize elicitation problems and increase the outcome (Brooks, 1995). Moreover, a proper way of communication is the key to elicit detailed ideas of the users that marks in the success of developed software (Expert, 2020).

Communication is one of the major causes during the phase of requirements elicitation that effects the outcomes (Coughlan, Lycett & Macredie, 2003). Success or failure of requirements is based on the ways of communications among participants (Holtzblatt & Beyer, 1995).

David and Gaurav (2017) indicated that communication strategies play a vital role during the process of elicitation towards the correct requirements. Researchers had worked on humor to increase the level of communications that interconnects the participants, enhances the quality and correctness of requirements elicitation in IT projects. A difficult way of communication between the stakeholders and analysts produces weak requirements elicitation (Davis, 1982). Communication is a fundamental part of elicitation process because this happens among the participants of diverse experiences and settings, therefore, mutual and established terminologies are required for the elicitation of successful requirements (Holtzblatt & Beyer, 1995).

2.6.1. Electronic Communication Tools
2.6.1.1. Audio Podcast
Audio podcast could be saved in smart phones and computers that could be heard at any time and any place (Sansinadi et al., 2020). Moreover, audio podcast is valuable to listen the recorded material from a saved audio file and helpful to convey the information (Rech, 2007).

Audio podcast works as a catalyst towards the formation of knowledge that could be used to listen through mobile devices, following the time and location of

convenience (Lee, McLoughlin, & Chan 2008). It is publicly known that an audio podcast has a power to boost the learning capability (Bob & Roisin, 2010). Audio podcast is an asynchronous type of communication that provides an opportunity of its usage according to a feasible schedule (Reese, 2015).

Siciliano et al. (2011) reported that participants favored audio podcasts as electronic tools of learning with constructive results. Moreover, audio podcasts are effective tools of communications through vocal information with a rapid growth of their popularity (Brooke, 2017).

2.6.1.2. E-mail

Electronic mail is easily accessible, speedy to access people and beneficial because of its simplicity in sending and receiving the messages (Vdovin, 2020).

E-mail is a relaxed method of conversation that empowers to create and send the messages in a short period (Yates & Orlikowski, 1992). Electronic mail is an easy way to spread information and access individuals with amazing skills (Ferris, 1993; Bachmann, Elfrink, & Vazzana, 1996; McManus et al., 2002). E-mail is an asynchronous type of communication that provides the chances of reading and replying the messages according to a flexible schedule (Reese, 2015).

Quaresma et al. (2013) stated that electronic mail is an important way of communication like other methods, such as telephone, facsimile or postal delivery. Electronic mail is a famous way of communication to easily access people (Prahl et al., 2015).

2.6.1.3. Online Chat Session

Online chatting is an electronic communicational tool that encourages efficient communications, helps in staying organized and leads to innovation (Kashyap, 2020). Online chat session stimulates attentive communications among the contributors that is useful in exchange of knowledge and process of learning (Kern, 1995; Whyte, 2000; Payne, & Whitney, 2002; Insinnia, & Eileen, 2004). Group members of online chat sessions can access, revise and reply to previous chats and develop effective ideas (Lafford, 2006). Moreover, online chat session is synchronous in nature that allows the participants to communicate in a real-time environment (Reese, 2015).

Online chat session motivates focused discussions, provide opportunities to exchange ideas and helps in rapid sending and receiving of information (Mynard, & Troudi, 2008; Isenberg, 2010; Harmon, Alpert, & Histen, 2014). Online chatting develops constructive thoughts, consequently, effects the end results of communications (Dowling, & Rickwood, 2014).

2.6.2. Interviewing through Electronic Tools

Text interviews (online chat sessions), e-mail interviews (e-surveying) and virtual interviews are useful electronic methods for conducting the electronic interviews (Dickson, Mavis, & Adu, 2020).

Audio podcast interview is a method of sending and asking the questions from interviewees, however, the process leaves understanding gaps because of its one-way mode of transmission (Rech, 2007).

Dana and Allen (2010) stated online chatting as a helpful medium to conduct online interviews, because of its real time communication between the interviewers and interviewees that is synchronous in nature. In addition, questioning can be done and modified according to real time replies.

E-mail interviews are effective in gathering of information because of their asynchronous nature; however, this way produces problems in relation to understanding and knowledge sharing that leaves knowledge gaps and cannot be a substitute of face to face interviewing (Ratislavová & Ratislav, 2014).

2.6.3. Discussion of Interview Agenda and use of E-Tools

Ahmad, Lu and Dweib (2014) stated that sharing the agenda of interview with the participants is a formal process that is used to provide an idea about the meeting, however, simply reading the agenda is insufficient to develop a clear picture towards the discussions of interview. The use of electronic communication tools such as, audio podcast, electronic mail and online chatting is for conducting the electronic interviews only (Ahmad, Lu & Dweib, 2016).

The agenda of an interview is forwarded to the interviewees to provide an idea about the discussions; however, merely reading the agenda cannot cover the understanding gaps that leaves ambiguities (Ahmad, Dweib, & Lu, 2016). The use of electronic communication tools including 'Audio Podcast', 'E-mail' and 'Online Chat Session' is purely for performing electronic interviews (Ahmad, Dweib, & Lu, 2017).

An interviewer sends pre-interview outline to the interviewees, entitled as agenda, for the purpose of creating an understanding in relation to the information going to be discussed during the process of interviews; nevertheless, this outline cannot deliver thorough advantage to the interviewees, because reading of an agenda for the development of concepts is highly challenging that leads to understanding gaps (Ahmad, Lu, & Dweib, 2017). Communications through electronic tools could play a vital role for the elicitation of requirements, however, currently the researchers are merely using the electronic communication tools for conducting the electronic interviews (Ahmad, Lu, & Dweib, 2014).

2.6.4. Requirements for Website Development
Usability is one of the major factors in the construction of a website and the design of a website based on user requirements is a significant feature (Rush, 2016; Nigel, James, & Susan, 2015). Users take maximum advantage from the content of a website (Fichter, 2013; Garret, 2010). The development of a website needs content and functionality requirements (Asprey, 2004). Functional requirements satisfy the desired needs of users and describe overall functionality of a website (Asprey, 2004; Hidalgo, & Fernandez, 2015). Following four sections are the requirements of a website development: (a) 'General'. (b) 'Functional'. (c) 'Usability'. (d) 'Content' (Ahmad, Dweib, & Lu, 2016). Collection of 'General', 'Functional', 'Usability', and 'Content', requirements are vital for the development of a website (Ahmad, Lu, & Dweib, 2017).

Table 6 summarizes the importance of communications during the process of elicitation, electronic communication tools including audio podcasts, e-mails and

online chat sessions, interviewing through electronic tools, discussions of interview agenda, use of audio podcasts, e-mails, online chat sessions, and requirements for website development.

Table 6. Communications, electronic communication tools, interviewing through electronic tools, discussion of interview agenda and e-tools, requirements for website development.

Literature	References
A proper way of communication is the key of software success.	(Expert, 2020)
Communication strategies play a vital role for the practice of elicitation.	(David & Gaurav, 2017)
Requirements elicitation is a process of communication.	(Yousuf & Asger, 2015)
Communications directly affect the requirements elicitation.	(Coughlan, Lycett & Macredie, 2003)
Communication with different ways increases the outcomes and decreases problems.	(Brooks, 1995)
Success or failure of requirements is centered on ways of communications.	(Holtzblatt & Beyer, 1995)
Audio Podcast:	
- delivers information that could be heard anytime.	(Sansinadi et al., 2020)
- is an effective tool for transmission of information.	(Brooke, 2017)
- produces constructive results on learning.	(Siciliano et al., 2011)
- boosts the learning capability.	(Bob & Roisin, 2010)
- works as catalyst for knowledge formation.	(Lee, McLoughlin, & Chan 2008)
- is a valuable tool to listen and convey the information.	(Rech, 2007)
E-mail:	
- allows speedy access to people.	(Vdovin, 2020)
- is a famous method to access people.	(Prahl et al., 2015)
- is an important way of communication like other methods.	(Quaresma et al., 2013)

- provides opportunity to access individuals with amazing skills.	(Ferris, 1993; Bachmann, Elfrink, & Vazzana, 1996; McManus et al., 2002)
- is an easy way to create and send messages in short period.	(Yates & Orlikowski, 1992)
Online Chat Session:	
- encourages efficient communications.	(Kashyap, 2020)
- stimulates attentive communications among the contributors.	(Kern, 1995; Whyte, 2000; Payne, & Whitney, 2002; Insinnia, & Eileen, 2004)
- allows the group members to access and revise previous chats that produces beneficial ideas.	(Lafford, 2006)
- motivates focused discussions and provides an opportunity to exchange ideas.	(Mynard, & Troudi, 2008; Isenberg, 2010; Harmon, Alpert, & Histen, 2014; Dowling, & Rickwood, 2014)
- Electronic interviewing through texting (online chat sessions), e-mailing and virtual meeting is a beneficial method of interviewing.	(Dickson, Mavis, & Adu, 2020)
- Audio podcast interview: is a method of sending and asking interview questions, however, this technique produces understanding problems because of its one-way communication mode.	(Rech, , 2007)
- Online chat session: is a helpful medium for interviewing because of its real time two-way communication mode.	(Dana, & Allen, 2010)
- E-mail is beneficial for information collection, however, it has problems towards understanding and knowledge sharing because of its asynchronous mode.	(Ratislavová & Ratislav, 2014)
- Use of and electronic tool for the purpose of interviewing leaves knowledge gaps, therefore, it cannot be a replacement of face to face interviewing.	(Ratislavová & Ratislav, 2014)
- Sharing the agenda of interview meeting with the interviewer is a formal process, however, reading only is inadequate to develop clear ideas. The use of	(Ahmad, Lu, & Dweib, 2014; Ahmad, Dweib, & Lu, 2016; Ahmad, Lu, & Dweib, 2017)

electronic communication tools like 'Audio Podcast', 'E-mail' and 'Online Chat Session' is purely for the electronic interviewing.	
- Usability is one of the major factors in the construction of a website.	(Rush, 2016; Nigel, James, & Susan, 2015)
- Content of a website in an importance factor in its development.	(Fichter, 2013; Garret, 2010)
- Website construction needs content and functionality requirements.	(Asprey, 2004)
- Functional requirements support in fulfilling the desired requirements of a website.	(Asprey, 2004; Hidalgo, & Fernandez, 2015)
- 'General', 'Functional', 'Usability', and 'Content' are the main requirements to develop a website.	(Ahmad, Dweib, & Lu, 2016)
- Gathering of 'General', 'Functionality', 'Usability', and 'Content', requirements are vital for the development of a website.	(Ahmad, Lu, & Dweib, 2017)

2.7. Challenges and Opportunities in Tacit Knowledge Elicitation

Hayek (1945) claimed about tacit as an unspoken knowledge that needs to be expressed properly by people, and its accurate elicitation could be beneficial to empower the commercial markets. Hayek is the founder of tacit knowledge and Polanyi continued his mission (Reichental, 2006).

Polanyi (1967) discussed the term tacit as an ability of people to hold the knowledge that cannot be completely shared because of difficulties in describing. In addition, technical and systematic detection is an important requirement linked to the experience of people; hence, main source of explicit is tacit because all the explicit knowledge comes from it.

Berry (1987) debated about the differences in tacit knowledge, since some sort of knowledge is convertible to explicit, conversely, other is challenging. Berry performed a case study to construct a type of laser through the attempts of participants. However, the laser did not work, because each stakeholder supposed that significant details were expressed. The problem was with the length of one lead. Practitioners ignored to recommend the substantial property linked to tacit knowledge. Hence, tacit knowledge is difficult to share, even if it is enquired through proper questioning and this sort of knowledge is the paramount challenge.

Nonaka (1991) proposed a model of knowledge conversion, termed as "knowledge spiral". The model had explained that tacit (implicit) knowledge transfers to tacit and stays tacit is called as "socialization". The combination of explicit to tacit constitutes "Internalization", tacit to explicit is called as "externalization" and explicit to explicit constitutes "combination", as follows:

	Tacit	Explicit
Tacit	Socialization	Externalization
Explicit	Internalization	Combination

Knowledge conversion model, offered by Nonaka.

Nonaka and Takeuchi (1995) proposed a model of knowledge-generation that had expressed the availability of explicit and tacit knowledge in an organizational environment and the importance of task forces in creating the knowledge. However, the researchers had claimed that conventional top to bottom organizational structure does not assist towards prevalent ability of generating fresh knowledge and its distribution through the organization.

Xiaodong (2018) offered a model of tacit knowledge management cycle for the analysis of knowledge sharing problems within the researched case company. The researcher had focused on inner issues influencing the process of tacit knowledge elicitation. This model had purely inspected the issues related with knowledge sharing and the factors influencing them. Nevertheless, there was no solution towards the bridging of understanding gaps between interviewers and interviewees towards the shared goals.

Minrata et al. (2020) developed a model of tacit knowledge extraction and reported the key findings of major challenges, including lack of users' contribution, preparation and misinterpretation of asked questions in the interviews. Therefore, the gaps of understanding between interviewers and interviewees need to be filled, towards the common goals.

Stephen et al. (2020) developed a Wargame-Augmented Knowledge Elicitation (WAKE) method to detect the information requirements through Human Machine Interface (HMI). Researchers used observations, probing and design thinking techniques. Nevertheless, major drawback in this method was the need of end users to understand the game. Moreover, its analysis was time consuming, because they had to follow multiple techniques to review the video footage for writing down the information. Hence, the gaps of understanding towards common objectives were unfilled, since a machine cannot be the replacement of human intelligence.

Dwitam and Rusli (2020) asked users to tell their stories in personal wordings and interpreted these stories for understanding system requirements; however, the gap

of understanding remained uncovered, since users explained their ideas in personal vocabularies.

The literature in this Chapter reveals a significant reason pertinent to this research because the elicitation of tacit knowledge is challenging that results in weak requirements; therefore, further efforts are required towards the proper elicitation of tacit knowledge.

2.8. Summary

The research area of this thesis is involved in the view of tacit knowledge elicitation. This Chapter comprised: an awareness about the existing position of software success, failures and delays, reasons for software failures and delays, software engineering body of knowledge, requirements engineering, requirements elicitation, types of knowledge, knowledge transfer, user sharing skills, elicitation techniques, interview technique for elicitation, discussion of interview agenda, use of electronic communications for communication purposes, available methods, challenges and opportunities in elicitation of tacit knowledge. All the above mentioned areas are relevant and thought-provoking to an extensive group of ICT professionals, computer science experts, academicians and specialists.

Literature review has explained that software engineering body of knowledge endeavors to maintain regularization in current areas and look forward to find new solutions to existing problems (V3, 2020). The overall success of software is less than its failure, cancellation or delays (Standish, 2016). Collection of weak requirements is one of the major reasons for software failures (Expert, 2020, Davey

& Parker, 2015; Gibbs, 2015). Erroneous elicitation of tacit knowledge produces weak requirements (Suryaatmaja et al., 2020; Casselman & Samson, 2005). Therefore, the challenge of tacit knowledge elicitation is significant for this study.

Tacit knowledge has its origin to the work done by its pioneers Hayek (1945) and Polanyi (1967). During the process of elicitation, explicit knowledge could be extracted easily, however, tacit knowledge is difficult to elicit (Nonaka & Takeuchi, 1995; Suryaatmaja et al., 2020). Provision of agenda to interviewees for reading is a practice to develop understanding towards the meeting of interview (Berg, 2007; Martin & Quan-Haase, 2013). However, reading of agenda is not enough to create a deep understanding of interview (Ahmad, Lu, & Dweib, 2017). The weakness in user sharing skills is one of the major reasons resulting in weak requirements gathering that affects the success of developed software (Expert, 2020). There is no organized training technique towards the development of user requirements elicitation skills (Ascaniis, et al., 2017). Communicational strategies play a vital role during the process of elicitation towards the correct requirements (David, & Gaurav, 2017). Moreover, suitable ways of communication are required to elicit in depth ideas of users (Expert, 2020). Users perform communications in a better way through synchronous and asynchronous communications (Reese, 2015). Synchronous is the real-time communication, like online chat sessions, however, asynchronous communication is based on anytime usage like reading and replying of e-mails or listening of audio podcasts according to the flexible schedules (Reese, 2015). Presently, a famous way of connection around the world is through the use

electronic communication tools with many communicational benefits, including audio podcasts (Sansinadi et al., 2020), e-mails (Vdovin, 2020), and online chat sessions (Kashyap, 2020). Electronic interview has benefits, nevertheless, does not bridge understanding gaps between the interviewers and interviewees, and some other methods are required to overcome these problems (Barratt, 2012; Pearce, Thøgersen-Ntoumani, & Duda, 2014). Hence, based on offered literature, the researcher has attained a base of using electronic communications tools including 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' (a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session'), to discuss the detailed pre-interview agenda with the interviewees, to enhance their sharing skills, and to bridge the gaps of understanding towards shared goals for the elicitation of tacit knowledge.

CHAPTER 3

METHODOLOGY

3.1. Methodology (Concurrent Triangulation Design for Mixed Methods)

The study was centered on the concurrent triangulation design for mixed methods. Salmon (2016) explained that the concurrent triangulation design for mixed methods is an effective technique because it has simultaneous timings for the collection of quantitative and qualitative data (for hypotheses and interviews) through similar phase of research that involves in collection, analysis and integration. Hypothetico-deductive method was used for the hypotheses testing that is expressed in following steps by Sekaran & Bougie (2016):

1). Identification of a wide problem area

2). Defining the problem statement

3). Hypothesis formulation

4). Deciding the measures

5). Gathering of data

6). Analysis of data

7). Data interpretation for finding out the results

Creswell and Plano (2007) defined the concurrent triangulation design for mixed methods with following four steps:

1. Quantitative data collection, analysis and results

2. Qualitative data collection, analysis and results

3. Mixing (the outcomes of quantitative and qualitative data for validation through results)

4. Interpretation (outcomes of quantitative and qualitative data)

Grounded theory is a practice of building the theory on methodic collection that starts with a research question, gathering of qualitative data, conversion of data in numbers, grouping of numbers, conversion into categories and these categories develop the foundation of new theories (Faggiolani, 2011; Allan, 2003; Strauss, & Juliet, 1994). Therefore, the research question was analyzed through grounded theory for semi-structured interviews.

Following are simple steps of grounded theory (Dick, 1990; Bryant, 2017):

1. Collection of data through interviewing

2. Taking the notes after every question

3. Conversion of extracted data in codes

4. Sequencing the data in clear order

5. Sorting the data under categories

6. Analyzing the data and interpreting the results

Elicitation of tacit knowledge is a difficult task (Suryaatmaja et al., 2020). Initial exploration confirmed that elicitation of tacit knowledge is continuously a challenging task (Cass, 1998; Hafeez et al., 2014; Suryaatmaja et al., 2020). In addition, there are continuous openings to suggest different methods of elicitation for tacit knowledge (Finkelstein, 1994; Avgeriou, et al., 2011; Minrata et al., 2020). Therefore, the area of tacit knowledge elicitation was suitable for the scientific investigation. The researcher recognized that there was a substantial requirement of empirical evidence to test the effects of interview techniques for the elicitation

of tacit knowledge to assess the opposing assertions of interview technique by Hart (1985), Ho (2006) and Malik et al. (2020). Electronic communications are used for interactions including many benefits, such as audio podcasts (Sansinadi et al., 2020), e-mails (Vdovin, 2020) and online chat sessions (Kashyap, 2020). Weak requirements elicitation is constantly referred as one of the major barriers in the success of software (Davey & Parker, 2015; Gibbs, 2015; Expert, 2020). Researcher found that provision of pre-interview agenda was an effort to move the interviewers and interviewees towards a common goal of understanding; however, this practice was merely based on reading the information of agenda (Ahmad, Lu, & Dweib, 2017). Therefore, this study had used electronic communication tools (audio podcast, e-mail and online chat session) to discuss the details of pre-interview agenda with the interviewees. Two hypotheses were tested, followed by one research question. The Concurrent triangulation design for mixed methods (Creswell & Plano, 2007) was selected for the research.

The study was focused on the elicitation phase of software development, to elicit the knowledge that was intended towards the development of a course website, as a small software project, for the participants studying the course "Computing Skills". This study was based on the concurrent triangulation design for mixed methods. Hence, the survey questionnaire (Appendix C) was used to collect data for 'Before' and 'After' the use of each electronic communication tool towards quantitative collection; to test both the hypotheses. This questionnaire was based on 10 point Likert scale, including (1) 'Strongly disagree'. (2) 'Disagree'. (3)

'Moderately disagree'. (4) 'Mildly disagree'. (5) 'Very mildly disagree'. (6) 'Very mildly agree'. (7) 'Mildly agree'. (8) 'Moderately agree'. (9) 'Agree'. (10) 'Strongly agree'. The selection of 10-point Likert scale is corresponding to the endorsement of Wittink and Bayer (2003), as follows: 10-point Likert scale offers better dispersion of data, degree of measurement accuracy and improved results to discover the variations compared to 4, 5 and 7-points Likert scales.

Approval was taken from the researcher's organization for distributing the survey questionnaires and conducting the interviews (Appendix A).

The number of participants was 120 with 19 years of age and similar cultural background. Cultural difference impacts the capability of assertiveness that is the expressing competency of an individual to convey the thinking (Niikura, 1999; Lee & Bradley, 2002). In addition, cultural difference could affect the process of requirements elicitation (Mahraz, Benabbou, Berrado, 2018; Sadig & Sahraoui, 2017).

Seniority in age helps to understand and perform in a better way as compared to juniors that is termed as relative age effect (Musch & Grondin, 2001; Wattie, Cobley & Baker, 2008). In addition, the age difference is a controlling variable, because elder individuals possess different levels of skills and capabilities as compared to youngers (Johnson, 2005). Therefore, this study was in the need of participants from similar cultural background with matching age group for the purpose of consistency and reliability of outcomes; consequently, the participants studying the course were selected because of suitability in the required criteria.

It should be deliberated that if the same research is conducted in different environment may produce different results, based on different age groups or diverse cultural backgrounds.

Initially, three introductory sessions were arranged for each group. First session was organized to provide the overall ideas about the research project and to hand over the consent forms ('Participant Acceptance Form with Study Details' - Appendix B). Second session was planned to collect the consent forms and equal division of participants to four electronic communication groups, randomly, as follows:

Group 'A': 30 participants for 'Audio Podcast'.

Group 'B': 30 participants for 'E-mail'.

Group 'C': 30 participants for 'Online Chat Session'.

Group 'D': 30 participants for 'Hybrid'.

Third session was organized to inform them about the use of 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid' as electronic communication tools based on their groupings, details of the pre-interview agenda discussions for the period of one month, notes-taking during the interviews, existence of two people (comprising the interviewer plus an associate for notes-taking), confidentiality of the collected data for the research purposes only, an overview of the interview essentials, location of interviews, timings, consent for the recording or non-recording of interview, information about the organization of discussions and delivery of pre-

interview agenda in four divisions for the duration of four weeks, as follows: ('Week 1) 'General requirements'. (Week 2) 'Functionality requirements'. (Week 3) 'Usability requirements'. (Week 4) 'Content requirements'. After these sessions, participants of each group were requested to furnish their feedback through survey questionnaires (Appendix C) at before stage for the key areas, as follows: (1) 'Friendly'. (2) 'Comfortable'. (3) 'Essential'. (4) Help of e-tool in 'Understanding' the requirements of interview. (5) Help of e-tool in 'Learning' the requirements of interview. (6) Help of e-tool in the process of 'Tacit Knowledge Elicitation'. Participants were informed that after the use of electronic communication tools post interview feedback will be collected again on the survey questionnaire (Appendix C). In addition, they were told that their names were not required on the survey questionnaires.

Audio podcasts were recorded using 'Audacity' and provided to the participants of group 'A' to convey the details of pre-interview agenda. This was a method of one-way asynchronous communications because the participants of this group had listened to the 'Audio Podcasts', only. They were forbidden to ask questions and requested to explore the answers of their questions through internet and other resources, if required. Group 'B' was communicated through 'E-mails' that is a method of two-way asynchronous communications and these participants were allowed to ask questions using e-mails. Communications with group 'C' were done through 'Online Chat Sessions' (through chat rooms of 'Moodle', a learning management system) that is a method of two-way synchronous communications

and these participants were allowed to ask questions in real-time communications. Group 'D' was connected through the blend of all three modes as 'Hybrid' (a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session'). The first area of the interview questionnaire 'General' (Appendix D) was divided in two parts during week-1 for all the groups that had the definitions and details of interview discussions. Likewise, 'Functionality', 'Usability', and 'Content' requirements were divided in two parts for the weeks 2, 3, and 4 with the similar plan. Therefore, group 'A' was provided the audio podcasts through DVDs and USB flash drives, twice in a week. Group 'B' had received two e-mails per week. Group 'C' had used the online chat sessions two times a week. Group 'D' had experienced the hybrid mode (a combination of audio podcasts + e-mails + online chat sessions) twice a week.

After using the electronic tool, each participant had attended the semi-structured interview for the collection of qualitative data through the questionnaire (Appendix D) towards four areas ('General', 'Functionality', 'Usability', & 'Content' requirements). Interview was started with a welcome message towards joining the interview, then warmup questions were asked, including "Welcome to the interview", "How are you?", "What interesting did you do during the last week end?", "Feel free to ask any question during the interview", and "If you have any question right now, ask it without any hesitation?". Participants were informed that interviewer could use additional assisting words to move the attention of interviewees towards the correct direction of discussions: termed as "prompting"

(Merriam-Webster, n.d.). In addition, detailed exploration of the inquired questions could be done: termed as "probing" (Merriam-Webster, n.d.). First question of each section [question numbers 1, 6, 11-a, and 16 such as 'Define the term WWW'] was designed for the smooth transition to the next questions since participants were students studying the course and were provided these definitions during the discussions. Therefore, these questions (1, 6, 11-a, and 16) are excluded from the analysis.

After attending the interview each participant was requested to fill in the survey questionnaire (Appendix C) for the after stage (after using the electronic communication tool and interview). After the collection of data, analysis was done to conclude the effects on the tested hypotheses and to answer the research question. The results of this study are available in next Chapter and published in an international conference and two refereed international journals (Ahamd, Lu, & Dweib, 2014; Ahmad, Dweib, & Lu, 2016; Ahmad, Lu, & Dweib, 2017).

(Note: the results of the first experiment using 'Audio Podcast' with group 'A' was presented in the Elsevier's conference (Ahmad, Lu, & Dweib, 2014). Initially, the research was planned to analyze ten key areas from survey questionnaire, including 'Friendly', 'Comfortable', 'Essential', 'Interviewer only', 'Interviewer with electronic communication', 'Understanding', 'Learning, 'Collection of ideas', 'Organization of ideas', and 'Presentation of ideas' (Appendix C)). The conference feedback and recommendations from field experts were discussed with the supervisory team, as a result focus of the research was narrowed to six key areas

including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', and 'Tacit Knowledge Elicitation' for the survey questionnaire (Appendix C) through semi-structured interview (Appendix D).

The quantitative analysis (Appendix C) was done through t-Test paired two sample for Means for testing the first hypothesis and One Way Anova - Single Factor ('After' attending the interviews) was used for testing the second hypothesis. To answer the research question using qualitative data analysis (Appendix D), each interviewee's knowledge was converted on 5 point Likert scale, including (1) 'Poor knowledge'. (2) 'Basic knowledge'. (3) 'Good knowledge'. (4) 'Very good knowledge'. (5) 'Best knowledge', for four questions of each section (except first question of every section, including (i) Question number 1. (ii) Question number 6. (iii). Question number 11-a. (iv) Question number 16). The overall results for each group is offered through 'Spider chart' for the comparisons among four areas of the questionnaires, including (1) 'General'. (2) 'Functionality'. (3) 'Usability'. (4) 'Content'. The summary of overall comparisons for qualitative data is provided in tabulated form and the 'Comparison chart' is used to illustrate percentage of prompting for each group.

3.2. Particular Procedure Employed

3.2.1. Performed the Literature Review

There is a diversity and richness in the body of knowledge in software engineering that is measured as a science towards many research openings; therefore, it is counted as a subdivision of software engineering (Zave, 1997; V3, 2020).

Requirements elicitation in requirements engineering has an important role in the software development life cycle (V3, 2020). Therefore, the review of existing literature detailed in Chapter 2 was the motivation towards this research. Many resources were used to explore and review the literature including formal printed libraries, internet (World Wide Web) scientific databases, websites, conference proceedings and peer reviewed online journals.

3.2.2. Derived Hypotheses and Research Question

First Hypothesis:

The first hypothesis towards six key areas, including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', and 'Elicitation of Tacit knowledge' is obtainable in Chapter 1, under section 1.2 (research elements) of this thesis. The results of this hypothesis were published in a peer reviewed journal (Ahmad, Dweib, & Lu, 2016).

Second Hypothesis

The second hypothesis towards six key areas is obtainable in Chapter 1, under section 1.2 (research elements) of this thesis. The results of this hypothesis were published in a peer reviewed journal (Ahmad, Lu, & Dweib, 2017).

Research Question:

Research question is available in Chapter 1, under section 1.2 (research elements) of this thesis. The results of research question were published in a peer reviewed journal (Ahmad, Lu, & Dweib, 2017).

Following are the details of research question towards four areas:

Are there any differences in the effectiveness of electronic communication tools including 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid', for the elicitation of tacit knowledge in interview technique towards four areas including (1) 'General'. (2) 'Functionality'. (3) 'Usability'. (4) 'Content'?

3.2.3. Selected Electronic Communications to be tested

According to the research design (Figure 1) in Chapter 1 of this thesis, the author had intended to test the effects of electronic communications (on four electronic groups, including 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid') for the elicitation of tacit knowledge in interview techniques through the detailed discussions of pre-interview agenda with the interviewees and to conduct face-to-face semi-structured interviews.

3.2.4. Selected Research Instrument and Experiment

The survey questionnaire (Appendix C) was the instrument to test both the hypotheses. The interview questionnaire (Appendix D) was the instrument to answer the research question. This experiment was conducted with 120 participants divided into four equal groups of 30 participants for 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid'. Before starting the research project, author had arranged three introductory sessions to explain the process and related activities (further details of these sessions are available in section 3.1. of this Chapter). After the sessions, participants had filled the survey questionnaire (Appendix C), before using the electronic tools. Next step was the piloting of experiments, followed by interviews (face to face, semi structured - Appendix D). Finally, after the interviews

participants had filled the survey questionnaire (Appendix C). Therefore, hard copies were used for filling in the surveys (Appendix C).

3.2.5. Data Collection

Participants were informed that their names were not needed on the survey questionnaire because of the confidentiality of data. Hence, all questionnaires were unidentified for quantitative data (Appendix C) for before and after stages, and for qualitative data (Appendix D) towards semi-structured interviews. Participants had signed the consent forms ('Participant Acceptance form with Study Details' - Appendix B).

3.2.6. Analysis of Data

Microsoft Excel was used to key in the collected data. The t-Test Paired two sample for means was used to analyze the first hypothesis. This test is a statistical method to conclude mean differences among two sets of observations (Statistics, 2019). Gleichmann (2020) described that t-test Paired Two sample for means is used for two times on the same group of people, to calculate significant differences between the means towards before and after stages. Researcher had further explained that this test has two possible hypotheses, including null hypothesis H_0 signifies that there is no difference in effects between the means of two groups, and alternate hypothesis H_1 signifies that there is a difference between the means of two groups. Therefore, this test was appropriate to evaluate the first hypothesis (Appendix C) of this thesis.

One Way Anova-Single factor is a statistical method used to conclude significant differences among the means of three or more groups (ExcelEasy, 2019).

Mackenzie (2018) defined One-Way Anova as a major test in statistics that is powerful in providing the analysis of variances, beneficial in the evaluation of datasets, offers differences among three or more groups through comparisons targeting on one independent variable. Moreover, One-Way Anova has two possible hypotheses, including null hypothesis H_0 signifies that there is no difference among the three or more groups towards an independent variable, and alternate hypothesis H_1 signifies that there is a difference among three or more groups towards an independent variable. Therefore, this test was fit to evaluate the second hypothesis of this thesis (Appendix C, after attending the interview) towards six key areas of electronic communications, including 'Friendly', 'Comfortable', 'Essential', 'Help in understanding', 'Help in learning', and 'Tacit knowledge elicitation'. Qualitative data was collected through semi-structured interviews (Appendix D). The feedback of each interviewee was converted on a 5 point Likert scale under four areas, including 'General', 'Functionality', 'Usability' and 'Content'. The overall outcomes of each group were illustrated using 'Spider Chart' (a diagrammatic way of presenting multivariate data in the arrangement of a two-dimensional diagram for three or more quantitative variables (Fusion, 2019)) towards the comparisons among four areas. The summary of overall comparisons for qualitative data was illustrated through 'Comparison chart' for the percentage of prompting.

This research was based on the concurrent triangulation design for mixed methods. Hypothetico-deductive method was used to formulate both the hypotheses and

grounded theory was used to answer the research question. Finally, triangulation was done to validate the data from both the research methods.

3.2.7. Results and Conclusion

The analysis of data was utilized to test both the hypotheses and the research question. Results and conclusions are provided in Chapters 4 and 5.

3.3. Layouts of Results Presentation

The results of findings are explained by text descriptions, presented by charts and tables in this thesis.

3.4. Used Resources

There was no operational cost related with this study since it was conducted on the students studying the course. Researcher was the interviewer along with an assistant for notes taking during the interviews. There were 120 subjects contributed to this study. This number is substantial in comparison with studies done for assessing the effectiveness of any electronic tool towards major key areas: 71 subjects (Naqvi, 2006); 37 subjects (Naqvi, & Ajiz, 2006); 104 subjects (Ahmad & Al-Khanjari, 2016); 50 subjects (Ahmad, 2017); 28 subjects (Ahmad 2018). Contribution of each subject was from 45 minutes to 1 hour. The subjects were from the researcher's institution, had a strong background of using the web resources and other electronic related activities. Active contribution of the subjects and clarity in the processes of research made it a suitable atmosphere having a positive effect on validity.

3.5. Reliability and Validity

The first research instrument for the study was 'Appendix C', to collect the data for testing of both hypotheses using electronic communication tools towards following key areas: 'Comfortable', 'Essential', 'Friendly', e-tools help in 'Understanding' and 'Learning' the details towards a specific goal, and these areas were used in many studies (Naqvi, 2006; Naqvi & Ajiz, 2006; Ahmad & Al-Khanjari, 2016; Ahmad, 2017; Ahmad, 2018). Therefore, literature review had provided a suitable insight about the tested key areas for this research since these were used earlier by the researchers and peer-reviewed journals had published those outcomes. Author had published the results of this study (current section under discussion – Appendix C) in an international conference and two peer-reviewed journals (Ahmad, Lu, & Dweib, 2014; Ahmad, Dweib, & Lu, 2016; Ahmad, Lu, & Dweib, 2017).

Chesebro and Borisoff (2007) explained that grounded theory is inductive development of theory from the data. Therefore, the survey instrument (Appendix D) was designed on grounded theory to develop a theory from the data. Author had published the outcomes of 'Appendix D' in a peer-reviewed journal (Ahmad, Lu, & Dweib, 2017). This research was based on the concurrent triangulation design for mixed methods offered by Cresswell and Plano (2007). Therefore, internally this study has high validity because of triangulation that is the final step to compare the validity of qualitative and quantitative results. Triangulation in mixed methods brings novelty and advancement and produces satisfactory outcomes (Nigel, 2012).

3.6. Summary

The concurrent triangulation design for mixed methods offered by Cresswell and Plano (2007) was the base of this research. Hypothetico-deductive method was used to formulate the hypotheses, followed by the steps of Sekaran and Buogie (2016), including (1) Identification of a wide problem area. (2) Defining the problem statement. (3) Hypothesis Formulation. (4) Deciding the measures. (5) Gathering of data. (6) Analysis of data. (7) Data interpretation for finding out the results. Grounded theory was used for qualitative data offered by Dick (1990) and Bryant (2017) as follows: (1) Collection of data through interviewing. (2) Taking the notes after every question. (3) Conversion of extracted data in codes. (4) Sequencing the data in clear order. (5) Sorting the data under categories. (6) Analyzing the data and interpreting results.

The research method was adopted because of its high-degree of reliability as mentioned in the above paragraph. These steps can be used by other researchers, scholars, specialists and related institutes for the future work in relation to this research.

CHAPTER 4

RESULTS

4.1. Details of Research Study

The total number of subjects was 120, divided into four equal groups of 30 subjects, randomly, including 'A', 'B', 'C' and 'D', for four electronic communication tools, comprising: 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid', respectively. The agenda was discussed in details with the subjects before the meeting of interviews. This study had the objectives of testing the effects of electronic communication tools for the elicitation of tacit knowledge through interview technique. These groups had used asynchronous and synchronous electronic communication modes. An asynchronous mode allows the reading and replying of messages through electronic communications or listening of recorded information, according to flexible schedules; however, a synchronous mode is based on real-time communications (Reese, 2015). The group 'A' had listened to the audio podcasts as an asynchronous mode (one-way communications for listening only). Group 'B' was communicated through e-mails as an asynchronous mode (two-way communications). Group 'C' was communicated through online chat session as a synchronous mode (two-way communications). Group 'D' went through an asynchronous (one-way communications through audio podcasts) + an asynchronous (two-way communications through e-mails) + a synchronous (two-way communications through online chat sessions) modes. Table 7 explains the study details.

Table 7. Study details

Name of E-communication Group	Mode	One-Way / Two-Way Communication	Subjects	Group Name
Audio podcast	Asynchronous	One-Way	30	A
E-mail	Asynchronous	Two-Way	30	B
Online chat session	Synchronous	Two-Way	30	C
Hybrid (a combination of audio podcast + e-mail + online chat session)	Asynchronous + Asynchronous + Synchronous	One-Way + Two-way + Two-way	30	D

Subjects were informed about the details of research project with 3 opening sessions. First session was organized to give the overall awareness about the research project and to provide the consent forms. Second session was planned to take back the consent forms, and subjects were divided into four electronic communication groups, randomly. Third session was organized to inform them about the plan of the detailed discussions of pre-interview agenda including other details. Further information of these sessions are available in Chapter 3, under section 3.1.

Creswell and Plano (2007) defined following four steps for the triangulation design:

1. Quantitative data collection, analysis and results.

2. Qualitative data collection, analysis and results.

3. Mixing (the outcomes of quantitative and qualitative data for validation through results).

4. Interpretation (outcomes of quantitative and qualitative data).

Table 8 demonstrates the details of steps followed for conducting the research study.

Table 8. Steps for conducting the research (collection of data).

Step number	Description (for groups 'A', 'B', 'C' and 'D')
1	Filling of survey questionnaires (Appendix C) before the use of e-tool.
2	Detailed discussions of pre-interview agenda through e-tools for one month.
3	One-on-one semi-structured interviews (Appendix D) after doing the discussions through e-tools.
4	Filling of survey questionnaires (Appendix C) about the use of e-tool.

Interviews were conducted with each subject after discussing the details of pre-interview agenda through electronic communications. Table 9 demonstrates the details of interviews.

Table 9. Type of Interviews

Name of E-communication Group	Type of interviews
Group 'A' ('Audio Podcast')	One on one – semi-structured
Group 'B' ('E-mail')	One on one – semi-structured
Group 'C' ('Online chat session')	One on one – semi-structured
Group 'D' ('Hybrid' [a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session'])	One on one – semi-structured

4.2. Findings (Quantitative and Qualitative Analysis and Results)

To outline the research: effects of electronic communication tools on the elicitation of tacit knowledge on interview techniques is a function of discussing the details of pre-interview agenda before the process of interviewing through these electronic communications.

Next sections reveal the analysis of quantitative and qualitative data, collected to test the hypotheses and the research question. The results are organized according

to four steps, defined by Creswell and Plano (2007), those are explained in section

(4.1) of this Chapter.

4.2.1. Quantitative Analysis and Results
4.2.1.1. t-Test Paired Two Sample for Means (First Hypothesis)

The results of first hypothesis (offered in Table 1, Chapter 1) can be seen in Tables

10, 11, 12 and 13 for t-Test: Paired Two Sample for Means in relation to four

electronic communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat

Session', and 'Hybrid' towards six key areas (Ahmad, Dweib, & Lu, 2016).

Table 10. Summary of results for t-Test: Paired Two Sample for Means (e-tool: *Audio Podcast'*)

Key areas	P-Value	Outcome	Comments		Effect of Audio Podcast
Friendly	6.51233E-20	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Comfortable	9.00697E-19	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Essential	6.0233E-21	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Understanding	2.02E-23	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Learning	2.46544E-18	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Tacit knowledge elicitation	5.36508E-20	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Overall Key areas for Audio Podcast	**Overall Average of P-Value 5.81826E-19**	**<0.05 (Significant)**	**Overall Reject H_0**	**Overall $H_1 : \mu > 5$**	**Overall Positive**

Table 11. Summary of results for t-Test: Paired Two Sample for Means (e-tool: *'E-mail'*)

Key area	P-Value	Outcome	Comments		Effect of E-mail
Friendly	9.392E-22	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Comfortable	3.108E-22	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Essential	9.066E-21	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Understanding	1.56E-23	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Learning	1E-24	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Tacit knowledge elicitation	8E-25	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive

Overall Key areas for E-mail	Overall Average of P-Value 1.722E-21	<0.5 (Significant)	Overall Reject H_0	Overall $H_1 : \mu > 5$	Overall Positive

Table 12. Summary of results for t-Test: Paired Two Sample for Means (e-tool: 'Online Chat session')

Key areas	P-Value	Outcome	Comments		Effect of Online Chat Session
Friendly	1.2E-27	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Comfortable	4.2E-23	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Essential	9.68E-25	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Understanding	5E-28	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Learning	1.67E-22	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Tacit knowledge elicitation	1.8E-27	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Overall Key areas for Online Chat Sessions	Overall Average of P-Value 3.49E-23	<0.05 (Significant)	Overall Reject H_0	Overall $H_1 : \mu > 5$	Overall Positive

Table 13. Summary of results for t-Test: Paired Two Sample for Means (e-tool: '*Hybrid*')

Key areas	P-Value	Outcome	Comments		Effect of Hybrid
Friendly	4.6E-28	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Comfortable	1E-29	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Essential	2.117E-26	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Understanding	9E-29	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Learning	8.7E-28	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Helped in Tacit knowledge elicitation	7.78E-27	<0.05 (Significant)	Reject H_0	$H_1 : \mu > 5$	Positive
Overall Key areas for Hybrid	Overall Average of P-Value 5.06E-27	<0.05 (Significant)	Overall Reject H_0	Overall $H_1 : \mu > 5$	Overall Positive

4.2.1.2. One Way Anova - Single Factor (Second Hypothesis)

The results of second hypothesis (offered in Table 2, Chapter 1) can be seen in Tables 14, 15, 16, 17, 18, and 19 for One Way Anova: Single Factor that is the comparison of differences among four groups ('Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid') towards six key areas (Ahmad, Lu, & Dweib, 2017).

Table 14. Summary of results for One Way Anova: Single Factor (key area: 'Friendly')

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Friendly-Podcast	30	187	6.233	0.460		
Friendly-E-mail	30	211	7.033	0.654		
Friendly-Chatting	30	242	8.066	0.202		
Friendly-Hybrid	30	271	9.033	0.309		
ANOVA						
Source of Variation	SS	Df	MS	F	P-Value: IE-33 ⇨(P<0.05)	F crit 2.682
Between Groups	133.825	3	44.608	109.708		
Within Groups	47.166	116	0.406			
Total	180.991	119				

Table 15. Summary of results for One Way Anova: Single Factor (key area: 'Comfortable')

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Comfortable-Podcast	30	194	6.466	0.671		
Comfortable-E-mail	30	215	7.166	0.764		
Comfortable-Chatting	30	239	7.966	0.240		
Comfortable-Hybrid	30	272	9.066	0.271		
ANOVA						
Source of Variation	SS	Df	MS	F	P-Value: 1.934E-27 ⇨ (P<0.05)	F crit 2.682
Between Groups	112.2	3	37.4	76.831		
Within Groups	56.466	116	0.486			
Total	168.666	119				

Table 16. Summary of results for One Way Anova: Single Factor (key area: 'Essential')

Anova: Single Factor					
SUMMARY					
Groups	Count	Sum	Average	Variance	
Essential-Podcast	30	193	6.433	0.667	
Essential-E-mail	30	218	7.266	0.891	
Essential-Chatting	30	243	8.1	0.231	
Essential-Hybrid	30	274	9.133	0.395	

ANOVA						
Source of Variation	SS	Df	MS	F	P-Value: 1.207E-26 ⇨ (P<0.05)	F crit 2.682
Between Groups	120.066	3	40.022	73.226		
Within Groups	63.4	116	0.546			
Total	183.466	119				

Table 17. Summary of results for One Way Anova: Single Factor (key area: 'Understanding')

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Understanding-Podcast	30	195	6.5	0.672		
Understanding-E-mail	30	213	7.1	0.713		
Understanding-Chatting	30	241	8.033	0.240		
Understanding-Hybrid	30	275	9.166	0.419		
ANOVA						
Source of Variation	SS	Df	MS	F	P-Value: 5.38E-28 ⇨ (P<0.05)	F crit 2.682
Between Groups	121.866	3	40.622	79.418		
Within Groups	59.333	116	0.511			
Total	181.2	119				

Table 18. Summary of results for One Way Anova: Single Factor (key area: 'Learning')

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Learning-Podcast	30	185	6.166	0.419		
Learning-E-mail	30	215	7.166	0.764		
Learning-Chatting	30	237	7.9	0.506		
Learning-Hybrid	30	271	9.033	0.309		
ANOVA						
Source of Variation	SS	Df	MS	F	P-Value: 1.099E-29 ⇨ (P<0.05)	F crit 2.682
Between Groups	131.466	3	43.822	87.644		
Within Groups	58	116	0.5			
Total	189.466	119				

Table 19. Summary of results for One Way Anova: Single Factor (key area: 'Tacit Knowledge Elicitation')

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Tacit knowledge elicitation- Podcast	30	186	6.2	0.510		
Tacit knowledge elicitation- E-mail	30	218	7.266	0.754		
Tacit Knowledge Elicitation-Chatting	30	239	7.966	0.240		
Tacit Knowledge Elicitation-Hybrid	30	278	9.266	0.340		
ANOVA						
Source of Variation	SS	Df	MS	F	P-Value:2.3E-33 ⇨ (P<0.05)	F crit 2.682
Between Groups	148.825	3	49.608	107.562		
Within Groups	53.5	116	0.461			
Total	202.325	119				

4.2.1.3. Overall Average of Groups (Audio Podcast, E-mail, Online Chat Session and Hybrid) - for One Way Anova Single Factor: Figure 3

The average of groups for One Way Anova – Single Factor is graphically available in Figure 2 (Ahmad, Lu, & Dweib, 2017), demonstrates that participants had valued the electronic communication tools with clear differences in effectiveness among 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' towards six key areas, including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning' and 'Tacit Knowledge Elicitation'. Moreover, all the four electronic communication tools are exhibiting almost linear behavior, proving that each electronic communication has impacted its key areas with similar weight.
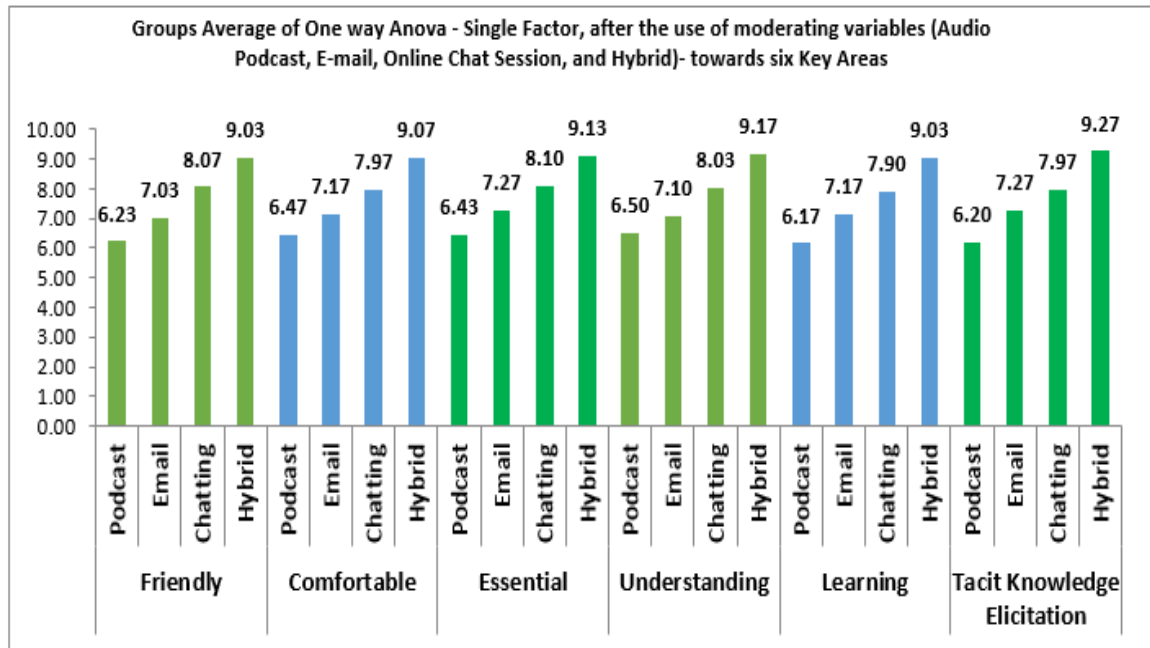
Fig. 2 overall average of groups ('Audio Podcast', 'E-mail', 'Online Chat Session', 'Hybrid') for One Way Anova – Single Factor – after using the electronic communication tools.

4.2.2. Qualitative Analysis and Results (Research Question)
Spider Chart

4.2.2.1. Outcomes of Audio Podcast communications on Group 'A' - Semi-Structured Interviews

Table 20 and spider chart in Figure 3 demonstrate the results of 'Audio Podcast'

usage on group 'A' towards four areas of semi-structured interviews, including

'General', 'Functionality', 'Usability' and 'Content'.

Fig. 3 spider chart – outcomes of interviews after using 'Audio Podcast' for the detailed discussions of pre-interview agenda with group 'A' (Ahmad, Lu, & Dweib, 2017).

Table 20. Arithmetic mean value of group 'A' ('Audio Podcast') towards four areas.

Area	Arithemetic Mean
General	77.7
Functionality	66.5
Usability	60.4
Content	63.7

4.2.2.2. Outcomes of E-mail communications on Group 'B' - Semi-Structured Interviews

Table 21 and spider chart in Figure 4 demonstrate the outcomes of 'E-mail' usage on group 'B' towards four key areas of semi-structured interviews, including 'General', 'Functionality', 'Usability' and 'Content'.
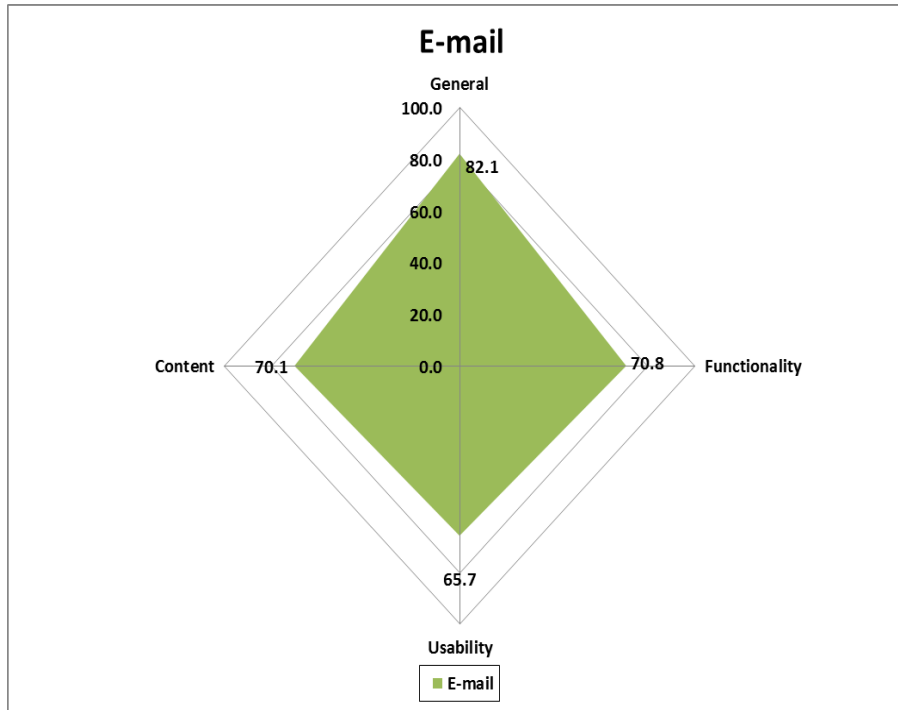
Fig. 4 spider chart – outcomes of interviews after using 'E-mail' for the detailed discussions of pre-interview agenda with group 'B' (Ahmad, Lu, & Dweib, 2017).

Table 21. Arithmetic mean value of group 'B' ('E-mail') towards four areas.

Area	Arithemetic Mean
General	82.1
Functionality	70.8
Usability	65.7
Content	70.1

4.2.2.3. Outcomes of Online Chat Sessions on Group 'C' - Semi-Structured Interviews

The results of semi-structured interviews after using the 'Online Chat Session' to discuss the details of pre-interview agenda with group 'C' towards four key areas, including 'General', 'Functionality', 'Usability' and 'Content' are offered in Table 22 and graphically available as a spider chart in Figure 5.
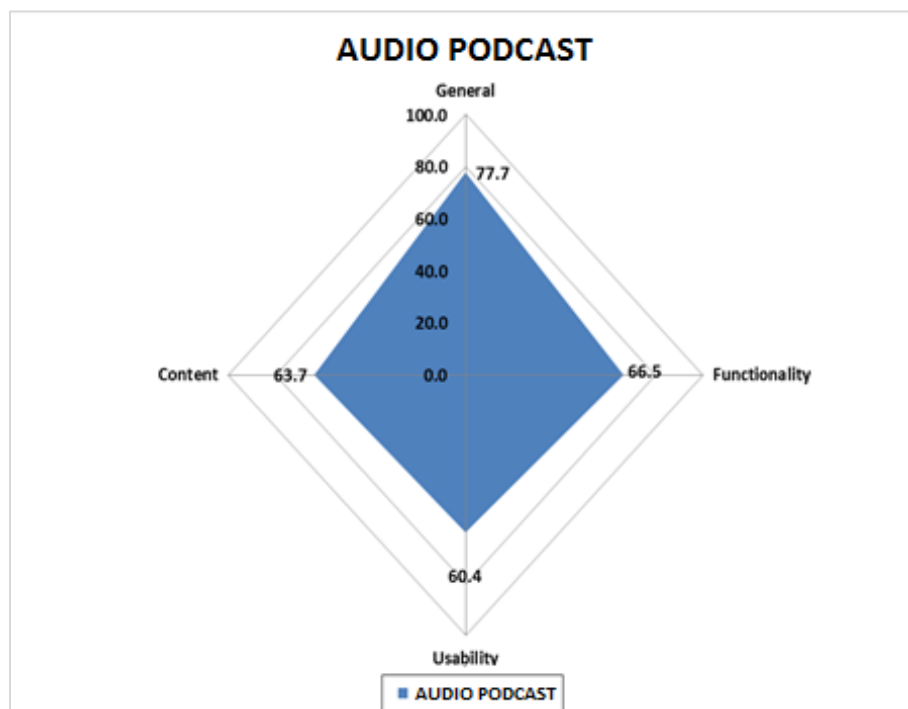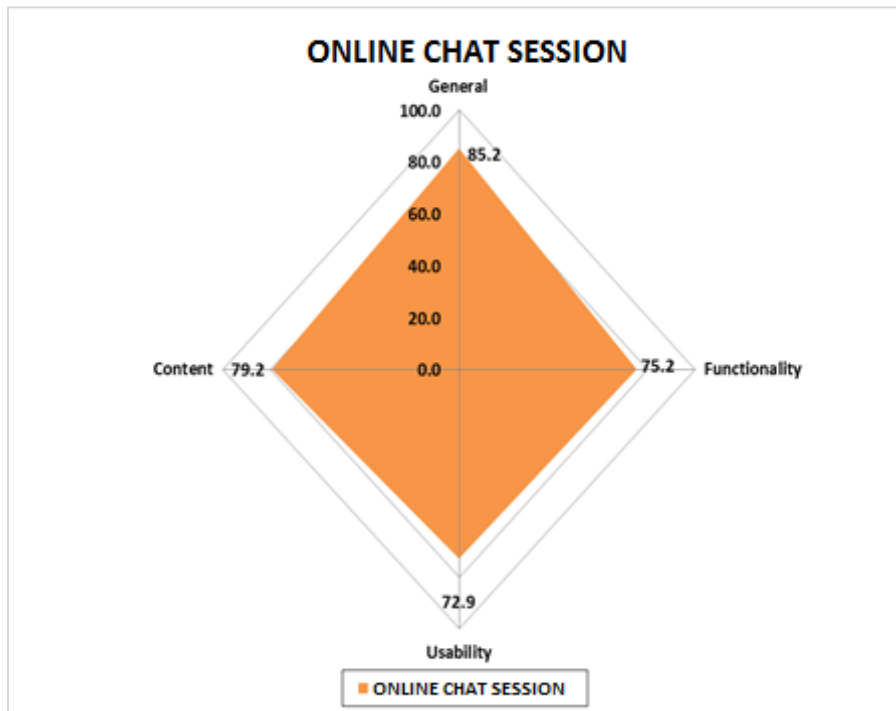

Fig. 5 spider chart – outcomes of interviews after using 'Online Chat Session' for the detailed discussions of pre-interview agenda with group 'C' (Ahmad, Lu, & Dweib, 2017).

Table 22. Arithmetic mean value of group 'C' ('Online Chat Sessions') towards four areas.

Area	Arithemetic Mean
General	85.2
Functionality	75.2
Usability	72.9
Content	79.2

4.2.2.4. Outcomes of Hybrid communications on Group 'D' - Semi-Structured Interviewing

The outcomes of semi-structured interviews after using the 'Hybrid' (a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session') communications with group 'D' towards four key areas, including 'General', 'Functionality', 'Usability' and 'Content' are obtainable from Table 23 and Figure 6 of the spider chart.
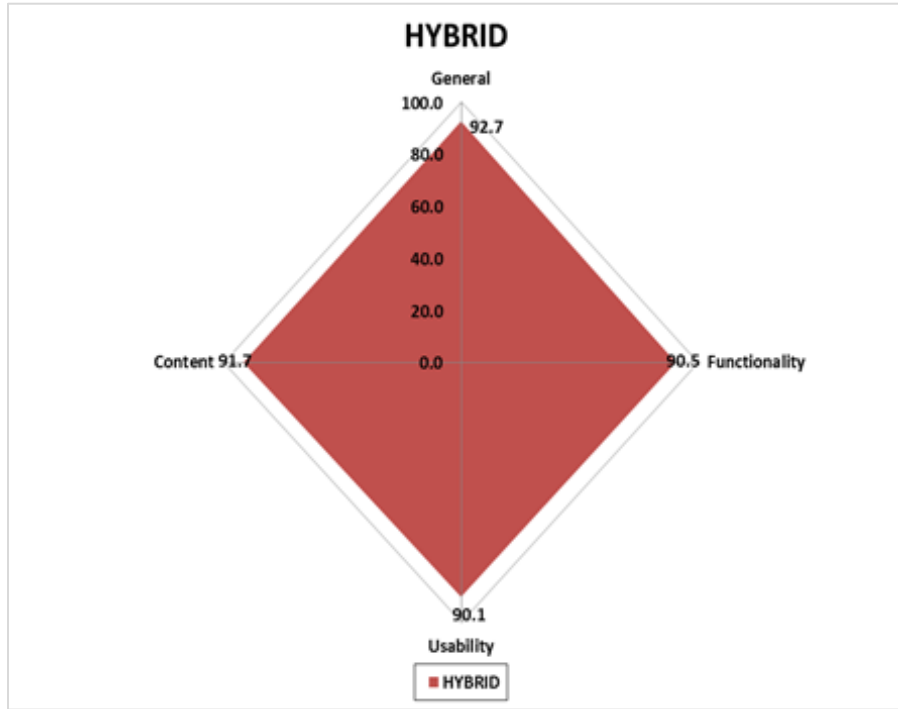
Fig. 6 spider chart – outcomes of interviews after using 'Hybrid' communications for the detailed discussions of pre-interview agenda with group 'D' (Ahmad, Lu, & Dweib, 2017).

Table 23. Arithmetic mean value of group 'D' ('Hybrid' [a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session']) towards four areas.

Area	Arithemetic Mean
General	92.7
Functionality	90.5
Usability	90.1
Content	91.7

4.2.2.5. Overall outcomes of electronic communications on Groups 'A', 'B', 'C' and 'D' - Semi-Structured Interviewing

Spider chat in Figure 7 displays an overall evaluation of the effects of 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' communications on the elicitation of tacit knowledge through the detailed discussions of pre-interview agenda on groups 'A', 'B', 'C' and 'D', towards four key areas ('General', 'Functionality', 'Usability', and 'Content') of semi-structured interviews. The overall percentage of arithmetic mean values for this section towards four key areas is available in Table 29, under section 4.2.3.2.1.
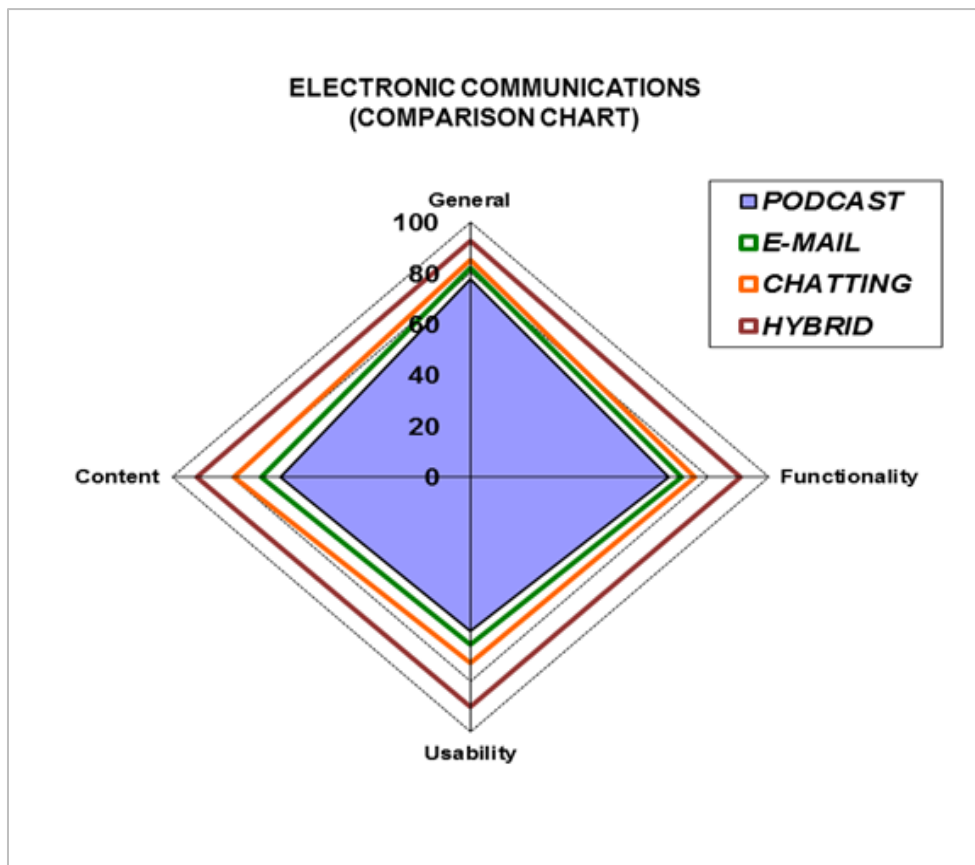

Fig. 7 spider chart – overall outcomes of interviews after using four electronic communications tools for the detailed discussions of pre-interview agenda with groups 'A', 'B', 'C' and 'D' (Ahmad, Lu, & Dweib, 2017).

4.2.2.6. Evaluation of Qualitative Data Collected Via Interviews

Table 24 summarizes the evaluation of collected data through semi-structured interviews.

Table 24. Evaluation of qualitative data collected through semi-structured interviews (Ahmad, Lu, & Dweib, 2017).

Audio podcast (group 'A')	E-mail (group 'B')	Online chat session (group 'C')	Hybrid (group 'D')
These interviewees had general awareness of the interview meetings. Few of them had ambiguities about some discussions. Many of them had said that they had ideas of asked questions, however, they could not explained it properly. Prompting was done for 21 participants out of 30 that is counted as 70 percent of prompting.	These interviewees had good ideas about the interview meetings. Only few of them had ambiguities about few questions. Some of them had said that they had ideas of the asked questions, however, they could not explain it properly. Overall, their explanations and vocabulary of interview meetings were good. Prompting was done for 12 participants out of 30 that is counted as 40 percent of prompting.	These interviewees had better ideas about the interview meetings, and their vocabulary was better. Most of them did not have any ambiguities. Their explanations were better and replies were confident. Prompting was done with 8 participants out of 30 that is counted as 27 percent of prompting.	These interviewees had best ideas, and excellent vocabulary about the interview meetings. They were clear about the asked questions. Their explanations were the best and replies were assertive. Prompting was done with 2 participants out of 30 that is counted as 7 percent of prompting.

4.2.2.6.1 Comparison Chart

Pushing the attention of an interviewee to the precise idea of asked questions during the interview is called 'Prompting' (Merriam-Webster, n.d.).

Figure 8 and Table 25 demonstrate the percentage of prompting for four electronic communication tools.
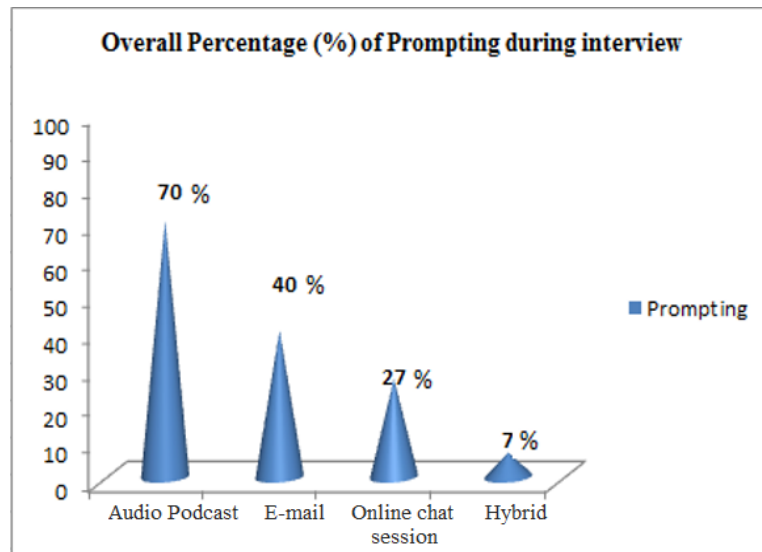

Fig. 8 percentage of prompting for four groups, including 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' (Ahmad, Lu, & Dweib, 2017).

Table 25. Percentage of prompting for four groups communicated through different electronic communication tools.

Electronic communication tool	Percentage of Prompting
Audio podcast	70%
E-mail	40%
Online chat session	27%
Hybrid	7%

4.2.3. Mixing (Outcomes of Quantitative and Qualitative data for Validation through Results)

a). Overall Quantitative Data Outcomes + b). Overall Qualitative Data Outcomes

4.2.3.1. Overall Quantitative Data Outcomes

4.2.3.1.1. Outcomes of Quantitative Data – [First Hypothesis] (t-Test Paired Two Sample for Means)

Table 26 demonstrates the overall outcomes and effects of t-Test paired Two Sample for means towards six key areas that is a collective summary of Tables 10, 11, 12 and 13.

Table 26. Overall outcomes of t-Test Paired Two Sample for Means - a collective summary of Tables 10, 11, 12 and 13.

E-tool / Key Area	Audio Podcast		E-mail		Online Chat Session		Hybrid	
	Outcome	Effect	Outcome	Effect	Outcome	Effect	Outcome	Effect
Friendly	Significant	Positive	Significant	Positive	Significant	Positive	Significant	Positive
Comfortable	Significant	Positive	Significant	Positive	Significant	Positive	Significant	Positive
Essential	Significant	Positive	Significant	Positive	Significant	Positive	Significant	Positive
Help in Understanding	Significant	Positive	Significant	Positive	Significant	Positive	Significant	Positive
Help in Learning	Significant	Positive	Significant	Positive	Significant	Positive	Significant	Positive
Help in Tacit Knowledge Elicitation	Significant	Positive	Significant	Positive	Significant	Positive	Significant	Positive

4.2.3.1.2. Outcomes of Quantitative Data – [Second Hypothesis] (One Way Anova – Single Factor)

Table 27 is presenting the overall outcomes of One Way Anova – Single Factor

towards six key areas that is a collective summary of Tables 14, 15, 16, 17, 18 and

19.

Table 27. Overall outcomes – One Way Anova Single Factor - a collective summary of Tables 14, 15, 16, 17, 18 and 19.

Use of electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid') on key area	Results	Remarks	
Friendly	Significant	Reject H_o	Difference in effectiveness
Comfortable	Significant	Reject H_o	Difference in effectiveness
Essential	Significant	Reject H_o	Difference in effectiveness
Helped in Understanding	Significant	Reject H_o	Difference in effectiveness
Helped in Learning	Significant	Reject H_o	Difference in effectiveness
Helped in Tacit Knowledge Elicitation	Significant	Reject H_o	Difference in effectiveness

4.2.3.1.3. Outcomes of Quantitative Data (*Average of four Groups from One Way Anova – Single Factor – Percentage of Results, Reference Figure 2)*

Table 28 demonstrates the overall results of average for all the four groups (reference: Figure 2).

Table 28. Overall average of four groups – percentage of results ('Audio Podcast', 'E-mail', 'Online Chat Session', 'Hybrid') towards six key areas (reference: Fig.2).

E-tool Percentage of outcomes towards key area	Audio podcast	E-mail	Online chat session	Hybrid
Friendly	62.30%	70.30%	80.70%	90.30%
Comfortable	64.70%	71.70%	79.70%	90.70%
Essential	64.30%	72.70%	81%	91.30%
Understanding	65%	71%	80.30%	91.70%
Learning	61.70%	71.70%	79%	90.30%
Tacit Knowledge Elicitation	62%	72.70%	79.70%	92.70%

4.2.3.2. Overall Qualitative Data Outcomes

4.2.3.2.1. Outcomes of Qualitative Data (Overall Percentage of Interview Results for Electronic Communications on Groups 'A', 'B', 'C' and 'D')

Table 29 demonstrates the percentage of results for semi-structured interviews towards four groups for four key areas that is a collective summary of Tables 20, 21, 22 and 23.

Table 29. Overall percentage of arithmetic means for four groups ('Audio Podcast', 'E-mail', 'Online Chat Session' & 'Hybrid') towards 'General', 'Functionality', 'Usability' and 'Content' - a collective summary of Tables 20, 21, 22 and 23.

Group *Area*	Group – 'A' ('Audio Podcast')	Group-'B' ('E-mail')	Group-'C' ('Online Chat Session')	Group-'D' ('Hybrid')
General	77.70%	82.10%	85.20%	92.70%
Functionality	66.50%	70.80%	75.20%	90.50%
Usability	60.40%	65.70%	72.90%	90.10%
Content	63.70%	70.10%	79.20%	91.70%

4.3.2.2. Outcomes of Qualitative Data (Evaluation of Qualitative Data Collected via Interviews through the Percentage of Prompting)

Table 30 demonstrates the overall percentage of prompting for semi-structured interviews.

Table 30. Percentage of prompting for four groups communicated through different electronic communication tools.

Electronic communication tool and group	Percentage of prompting
Audio podcast (group 'A')	70%
E-mail (group 'B')	40%
Online chat session (group 'C')	27%
Hybrid (group 'D')	7%

4.2.4. Interpretation

Gleichmann (2020) described that t-Test Paired Two Sample for Means is a powerful test to calculate significant differences between the means of same participants for before and after stages. The quantitative data outcomes of the first hypothesis through t-Test Paired Two Sample for Means, provided in Table 26

(section 4.2.3.1.1) are significant towards all the six key areas, including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', and 'Tacit Knowledge Elicitation', through the use of electronic communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid'. Therefore, H_0 is rejected, verifying that these are helpful electronic communication tools towards six key areas. The significant outcomes verify that the overall effect of each electronic communication tool is positive. Therefore, 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' are confirmed as friendly and comfortable tools, essential part of interview process, helpful in understanding and learning the interview requirements and useful in the elicitation of tacit knowledge. Consequently, there is a strong motivation towards the use of all these e-tools to discuss the details of interview agenda with the interviewees, before the process of interviewing. The results of first hypothesis prove that there are no limitations in using these e-tools.

One-Way Anova Single Factor provides the analysis of variances that is helpful in the evaluation of datasets and offers differences among three or more groups through targeting on one independent variable (Mackenzie, 2018). The quantitative data outcomes of the second hypothesis through One-Way Anova Single Factor, offered in Table 27 (section 4.2.3.1.2) are significant towards six key areas, including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning', and 'Tacit Knowledge Elicitation' through the use of e-communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat Session' & 'Hybrid'. Therefore, H_0 is rejected to verify that 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' have clear differences in effectiveness. The outcomes reveal that these

four electronic communication tools are beneficial with different levels of effectiveness. Hence, these e-tools can be used for the detailed discussions of pre-interview agenda with the interviewees and any one of these e-tools can be selected according to the feasibility of project.

The outcomes of second hypothesis clarify that 'Audio Podcast' is least effective because of its one-way asynchronous mode of communications to listen the information only. 'E-mail' has presented improved results than 'Audio Podcast' that is based on a two-way asynchronous communications. 'Online Chat Session' is based on a two-way synchronous communications that has provided enhanced results than 'Audio Podcast' and 'E-mail'. 'Hybrid' is proved one of the best solutions that is a combination of one-way asynchronous, two-way asynchronous and two-way synchronous communications. Based on the outcomes of second hypothesis, the feasibility of project can be a boundary towards the selection of 'Hybrid' as the tool of electronic communications.

4.3. Summary

This research was conducted to test the effects of electronic communications on the elicitation of tacit knowledge for interview technique through the detailed discussions of pre-interview agenda with the interviewees. The concurrent triangulation design for mixed methods was used through the feedback of subjects on the survey questionnaires (Appendix C) towards six key areas and interview questionnaires (Appendix D) towards four key areas, intended for the development of a website. Total subjects were 120, divided into four groups, including 'Audio

Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid'. The concurrent triangulation design for mixed methods defined by Creswell and Plano (2007) is as follows:

1. Quantitative data collection, analysis and results.

2. Qualitative data collection, analysis and results.

3. Mixing (the outcomes of quantitative and qualitative data for validation through results).

4. Interpretation (outcomes of quantitative and qualitative data).

Two hypotheses were tested towards six key areas including 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning' and 'Tacit Knowledge Elicitation'.

Quantitative data was collected and tested through t-Test Paired Two Sample for Means for the first hypothesis in relation to test the effectiveness of four electronic communication tools. The data was analyzed and results were presented in the form of tables. Second hypothesis was tested through One way Anova – Single Factor, to compare the differences in effectiveness among four e-tools. The data was analyzed and results were presented in the form of tables and a figure.

Qualitative data was collected through semi-structured interviews. The data was analyzed and results were presented in the form of spider charts and tables. Finally, the evaluations of qualitative data were completed based on the percentage of prompting.

Mixing was done for quantitative and qualitative data for the validation of results, based on the steps offered by Creswell and Plano (2007). Finally, interpretation for the outcomes of quantitative and qualitative data was done. Results were significant for both the hypotheses. The detailed discussions of pre-interview agenda was positively effective towards the technique of interview with different levels of effectiveness towards four electronic communication tools including 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid'. Therefore, these electronic communication tools are moderating variables towards the elicitation of tacit knowledge.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

5.1. Contributions

Elicitation is a practice to gather the requirements from stakeholders. Tacit knowledge is difficult to elicit that leads to weak requirements and one of the major reasons for software system failures. A state-of-the-art contribution of this study is the use of electronic communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid' as moderating variables for the elicitation of tacit knowledge through discussing the details of pre-interview agenda with the interviewees. Review of literature revealed that there are diverse areas of elicitation. Moreover, the use of electronic communications to discuss the details of pre-interview agenda with the interviewees is an innovative description of interview type.

This experimental research provides an opening for a new research area by the use of electronic communications for the detailed discussions of pre-interview agenda with the interviewees that work as moderating variables. Therefore, this type is an effective interview technique for the elicitation of tacit knowledge requirements. This is a novel method of interviewing that should be adopted by the interviewers to solve elicitation related problems because this is a constant challenge faced by the specialists. People have knowledge that cannot be shared properly because of their personal terminologies and vocabularies.

The detailed review of literature reveals that the use of electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session') is for daily communications and performing the electronic interviews. Gary, Joanne and Victor (2009) stated that audio podcasts are useful in conducting electronic interviews. Audio podcasts are used in sending the questions to interview participants (Rech, 2007). E-mail is a worthy tool to take the interviews (Bampton & Cowton, 2002; Hunt & McHale, 2007). Ratislavová and Ratislav (2014) maintained that e-mail interviews are worthy, asynchronous in nature and beneficial in the collection of qualitative data; however, this technique leaves understanding gaps and cannot be a replacement of face to face interview method.

Online chat sessions are effective for conducting the interviews because questions could be adjusted, depending on the replies of interviewees, and all these ways are simply used in conducting the interviews (Dana, & Allen, 2010).

Online chat sessions are effective ways to conduct the online interviews; however, this technique cannot fill understanding gaps between the interviewers and interviewees (Barratt, 2012).

Successful software projects were 29%; conversely, failed or challenged projects were 71% in 2015 (Standish, 2016). Total cost of software failure in 2016 (for 548 projects) was $1.1 trillion (Software, 2016). In addition, financial losses produced by software failures in 2017 (for 606 projects) were $1.7 trillion (Scott, 2018). Undo (2020) claimed that the cost of software failure in 2019 for North America was $1.2 trillion that is an estimated loss for every year. The delivery of interview agenda to interviewees is an effort to create understandings towards the shared

objectives between the interviewers and interviewees (Berg, 2007; Martin & Quan-Haase, 2013).

User requirements elicitation and understanding of requirements are main challenges during the practice of elicitation (Babak & Simeon, 2013; Standish, 2014; Blokdijk, 2015; Standish, 2016). Weak requirements elicitation is one of the main reasons triggering the software project failures (Standish, 2014; Naeem, Khalid, & Sami, 2013; Gibbs, 2015; Expert, 2020).

The concept of bridging the gap of understandings between interviewers and interviewees in relation to this thesis has its basis from the existing literature (Rech; 2007; Berg 2007; Barratt, 2012; Naeem, Khalid, & Sami, 2013; Babak & Simeon, 2013; Martin & Quan-Haase, 2013; Ratislavová & Ratislav, 2014; Standish, 2014; Blokdijk, 2015; Gibbs, 2015; Standish, 2016; Suryaatmaja et al., 2020).

The findings of this research are in contrast to the claim of Byrd, Cossick and Zmud (1992) stated that the major disadvantage of conversational interview technique for elicitation is the difficulty of controlling the performance of participants, those are the source of extraction. The results of this study are in disagreement with the statement of Ho (2006) stated that only the interviewing method is insufficient to elicit the tacit knowledge, hence interview method requires the integration of other techniques such as observation to elicit the detailed information. Moreover, the outcomes are in contrast to the statement of Malik et al. (2020) stated that interview method needs excessive efforts for the extraction of requirements with additional consumption of time.

Novel findings of this research are in agreement with Yousuf and Asger (2015) detailed that interviewing is a famous technique to extract the detailed knowledge from an individual and to endorse the requirements of software. The results of this study are in pact with Hamzah, Ghorbani and Abdullah (2009) identified that overall there are positive effects of electronic communications on the participants towards understanding, knowledge formation and gathering. Beg, Abbas and Verma (2008) stated that the agenda of interview should be provided to the interviewees, before the meeting of interview because reading of agenda creates an understanding towards the required information; however, the provision of interview agenda for one time reading is not enough to create a clear understanding towards the goal of interview.

The results of this research contribute to the body of knowledge with a novel approach that is friendly and comfortable for the participants of interviews. This study provides a set of electronic communication tools that helps in developing the common vocabulary towards interview meetings and bridges the understanding gaps between the interviewers and interviewees. This set of e-tools helps in understanding and learning the requirements of interviews and acts as moderating variables to improve the existing techniques of interview. Moreover, it helps in reducing the overall post development efforts of reworking, time and cost; consequently, it is going to increase the success rate of software to be developed. Therefore, the outcomes of this research are state-of-the-art.

This research delivers primary evidence that the use of electronic communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid' to

discuss the details of pre-interview agenda is an effective technique for the elicitation of tacit knowledge requirements. This is a novel interviewing method that is used to recognize how a specialist needs to approach the problem of elicitation. 'Hybrid' (a combination of 'Audio Podcast' + 'E-mail' + 'Online Chat Session') mode is the most effective e-communication technique for the detailed discussions of interview agenda through semi-structured interviews, because the rate of effectiveness is 92.7% towards the elicitation area 'General', 90.5%, 90.1% and 91.7% towards the areas 'Functionality', 'Usability', and 'Content', respectively. 'Online Chat Session' possesses the rate of effectiveness as 85.2%, 75.2%, 72.9%, 79.2%, 'E-mail' with 82.1%, 70.8%, 65.7%, 70.1%, 'Audio Podcast' with 77.7%, 66.5%, 60.4%, 63.7% towards above stated four elicitation areas, respectively. The results of this research negate any arguments offered in present literature that proper elicitation cannot be done with the interview technique only, and the technique is not suitable to elicit the tacit knowledge. Therefore, using these electronic communication tools to discuss the details of pre-interview agenda with the interviewees act as moderating variables towards the elicitation of tacit knowledge. In the author's view, this concluding statement is the most important outcome of this research.

Overall, this thesis has discussed the effects of four electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid'), those have operated as moderating variables for the elicitation of tacit knowledge through detailed discussions of pre-interview agenda. Two hypotheses were tested towards

six key areas and one research question was tested for four factors towards semi-structured interviews. The outcomes of both hypotheses have evidenced that every electronic communication tool is effective. Moreover, there are clear differences of effectiveness among these four electronic communication tools towards six key areas. The main purpose of this study is to draw the focus of software experts towards the use of these electronic communication tools from a different perspective that is in the direction of discussing the details of the pre-interview agenda, considering the feasibility of the project towards the choice of electronic communication tool. These electronic tools have operated as catalysts and positively influenced the key areas 'Friendly', 'Comfortable', 'Essential', 'Understanding', 'Learning' and 'Tacit Knowledge Elicitation'. The outcomes of spider chart gives an in-depth valuation of the research question, intended for the development of a website towards four areas ('General', 'Functionality', 'Usability', and 'Content'), and proved that these e-tools have operated constructively for the practice of elicitation, intended towards a small software development. Hence, these four electronic communication tools have developed a state-of-the-art interview technique.

The research outcomes motivate the use this interview technique for the elicitation of tacit knowledge through the use of four different electronic communication tools. This study was conducted for the elicitation of tacit knowledge on four diverse groups, intended towards the development of a small software. These kinds of small projects are mostly unheeded by the companies because they commonly focus on

large projects (Rosato, 2018). Supplementary research can be conducted to discuss the details of pre-interview agenda through these electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid'), for the elicitation of tacit knowledge towards the development of medium and large software projects. Future experiments can be done on these electronic communication tools including the participants from diverse cultural backgrounds, other groupings of electronic communication tools such as 'Audio Podcast + Online Chat Session', 'Audio Podcast + E-mail', 'Online Chat Session + E-mail', and other sorts of e-tools such as 'Video Chatting', 'Audio E-mails', forums, blogs and their diverse groupings.

This thesis offers experimental confirmation that the use of these electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session' and 'Hybrid') is very efficient towards the elicitation of tacit knowledge through interviewing. Surely, this state-of-the-art technique will help to improve the practice of tacit knowledge elicitation, intended for the development of software projects.

Taking into account the viability of projects, any one of the electronic tool can be used towards the bridging of understanding gaps between the interviewers and interviewees. 'Hybrid' is proved as best among all the four e-tools. Hence, it could be the prime selection to discuss the details of pre-interview agenda, if it is permitted by the feasibility of project. If the participants can manage to be online for real time conversations (synchronous mode) then 'Online Chat Session' could be one of the recommended choices. 'E-mail' communications could be selected as an alternate choice because of its asynchronous mode. The selection of 'Audio

Podcast' as a tool of communication for the detailed discussions of pre-interview agenda is a worthy choice for the participants, those could spare the time for listening through their portable electronic gadgets, since audio podcasting is asynchronous in nature with one-way of communications.

Hence, the results and analysis of these electronic communication tools confirm their effect as moderating variables for the elicitation of tacit knowledge through detailed discussions of pre-interview agenda with the interviewees that plays an important role in facilitating the advancement of enhanced understandings towards the queries, discussions, and matters going to be conversed during the meeting of interview. These e-tool are beneficial for interviewers and specialists during the phase of requirements elicitation towards the development cycle of software. Therefore, these electronic communication tools play an important part to transform the tacit knowledge to explicit that produces accurate requirements. Elicitation of accurate requirements leads to the success of software (Expert, 2020). The outcomes of this research are related with the popular 'Nonaka's Model' (Nonaka, 1991) that is linked to the elicitation of explicit and tacit knowledge because explicit knowledge is understandable and easily explainable. However, tacit knowledge is difficult to understand and explain. Most of our knowledge is based on tacit; therefore, if the elicitation of tacit knowledge is accurate then the outcomes would be successful projects (Nonaka & Takeuchi, 1995). Outcomes of this research are in agreement with the declaration of Dieste, Juristo, and Shull (2008) that the essential part of system development life cycle is the elicitation of

precise requirements, as a result, time and money could be saved and projects would be succeeded.

Review of literature informed that: there is a shortage of research towards the elicitation methods (Grabowski, 1988; Agarwal, & Tammiru, 1990; Byrd, Cossick, & Zmud, 1992; Finkelsteein, 1994). Moreover, elicitation of tacit knowledge is a challenging task (Cass, 1998; Hafeez et al., 2014; Suryaatmaja et al., 2020). Researchers have continuous openings to propose different techniques for the elicitation of tacit knowledge (Finkelstein, 1994; Avgeriou, et al., 2011; Minrata et al., 2020). Interview technique is a common practice for the elicitation of requirements (Grabowski., 1988; Purvis & Sumbammurty, 1997; Rogich, & Browne, 1998; Yousuf, Asger, 2015).

Detailed research is required for all the other famous methods of elicitation towards the use and effects of electronic communication tools because the devising of such a detailed research will provide an extensive standard of technique effectiveness to the specialists and field experts. In addition, it will offer a range of ways to the essential requirements to have a widespread body of knowledge in the area of software engineering. Precisely, interview is a famous technique for software development projects. The ultimate applied application of the outcomes in this thesis is to advance the elicitation method towards the development of quality software. Results of this thesis must enrich the existing literature, methods and techniques. Those organizations using the interview method for the elicitation of requirements must give a great importance to the outcomes of this study.

This thesis produces the base to evaluate the effectiveness of electronic communications for all the known methods of elicitation. Deficiency in evaluations is a major constraint towards the improvement and enrichment of software engineering as a recognized field (Wynekoop, & Russoo, 1995; Xiaodong 2018).

SWEBOK is the acronym for Software Engineering Body of Knowledge that is a standard for collectively acknowledged and recognized information of Software Engineering (V3, 2020). The results of this thesis should enhance and supplement the knowledge of requirements engineering for SWEBOK.

5.2. Implications

Elicitation of accurate requirements is a key of success for a software system (Expert, 2020). The outline of this thesis figures out towards the significance of accurate requirements. Literature of Chapter 2 reveals that weak requirements affect the output of projects that lead to extremely adverse results in the form of failure, cancellation, additional cost, suspension and execution of incompatible projects with disappointed end users. Today the digital world is pushing organizations to operate and communicate electronically because all the stakeholders demand excellence. However, failure leads to the collapse of organizations. Consequently, specialists from the academic world and industry pay special attention in empirical studies that can positively affect the process of software development. Specially, software developments are commonly using interview techniques for requirements elicitation and there is a deficiency in empirical research to strengthen its efficacy. There are many elicitation techniques

used in the market (Malik et al., 2020). If an interview technique is selected for the elicitation of tacit knowledge for the development of any software, specialists should take the notice towards the enrichment of effectiveness by using any of the electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session', or 'Hybrid') for detailed discussions of pre-interview agenda with the interviewees. The specialists should be assured that elicitation must be effective through this way of interviewing.

At an initial phase, every project passes through the stage of elicitation (V3, 2020). It is identified that an integration of electronic communications with the detailed discussions of pre-interview agenda plays an important part to elicit the tacit knowledge; therefore, this research concludes that the specialists need to be aware of this integration of electronic communications with the interview technique.

Should the specialists be acquainted with the differences in effects of e-communication types ('Audio Podcast', 'E-mail', 'Online Chat Session', or 'Hybrid')?

Certainly, specialists should be aware of the differences in the effectiveness of all the types of electronic communications, those are furnished through this empirical research. This research has primarily identified the differences in effects and revealed the range of effectiveness in ascending order (1. Highest to 4. Lowest) as follows:

1). 'Hybrid' (a combination of: 'Audio Podcast' – *'Asynchronous' [one-way communications]* + 'E-mail' – *'Asynchronous' [two-way communications]* + 'Online Chat Session' – *'Synchronous' [two-way communications]*).

2). 'Online Chat Session' – *'Synchronous' [two-way communications]*

3). 'E-mail' – *'Asynchronous' [two-way communications]*

4). 'Audio Podcast' – *'Asynchronous' [one-way communications]*.

Specialists should focus during the selection of any electronic tool towards the level of effectiveness and the feasibility of the project environment. They should select and adjust the e-tool for the interviews accordingly.

5.3. Recommendations and Future Research

This primary research towards the effects of electronic communications on interview technique for the elicitation of tacit knowledge, intended towards the development of a small software, verifies that these communications are positively effective. Moreover, electronic communication tools have different levels of effectiveness, ranging from higher to lower. Specialists should take care that there is a huge difference between 'Audio Podcasts' – *'Asynchronous' [one-way communications],* 'E-mail' – *'Asynchronous' [two-way communications]*, 'Online Chat Session' – *'Synchronous' [two-way communications],* and 'Hybrid' *[a combination of all the three e-tools]*. There is clear evidence about the highest effective e-tool 'Hybrid'. If the feasibility of project allows the use of all the three e-tools for 'Hybrid' then prime choice should be this tool because the selection of

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e-tool depends on the viability and environment of the project. Therefore, the research evidence recommends that tacit knowledge can be elicited at its maximum for software development projects through detailed discussions of pre-interview agenda with the interviewees through electronic communication tools because these e-tools act as moderating variables on the effectiveness of tacit knowledge.

The results of this research indicate that there is a huge scope to conduct the research in this field. This study does not focus into the following: cultural differences, electronic interviews through the use of these electronic communication tools, video interviews, video chatting, wikis, forums, audio e-mails, blogs and their blends. These areas can be used in future research through the application of this state-of-the-art interview technique to measure the effectiveness.

Newswire (2020) stated that information and communication technologies sector has experienced a surprising shock due to COVID-19 because many of the projects related with information and communication technologies are dropping their speed; consequently, resulting in delays or cancellations, based on the withdrawal of face to face activities and gatherings in relation to preventive measures. Dickson, Mavis and Adu (2020) detailed that during COVID-19 the practice of face to face interviews is not possible towards the gathering of required information, and proposed following techniques: telephonic interviews, virtual interviews and text based (online chat sessions) interviews, use of e-mails for interviews and e-surveying. Moreover, researchers had claimed that people depend on researchers to

discover practical solutions to solve the problems. Therefore, it is strongly recommended to use the electronic communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid' to discuss the details of pre-interview agenda with the interviewees to bridge the understanding gaps between the interviewer and interviewees, for the finest elicitation of tacit knowledge.

Brown (2019) detailed about the knowledge base as a centrally unified repository that is used to save, systematize, and share the data. In addition, its external use allow the people to fetch anything from an online self-service depository, including goods, services, subject areas, frequently asked questions, guidebooks and booklets. Shukla and Iriondo (2020) stated that computers work at their best with the stored information in tabulated form; nevertheless, users mostly communicate through typed text in the form of unstructured communications and computers cannot understand it very precisely. Natural language processing is a branch of artificial intelligence that is one of the solutions for this problem to comprehend the unstructured data and fetch meaningful portions (Shukla & Iriondo, 2020). A chatbot is a part of software that has the conversational capability with people operating on the natural language through artificial intelligence (Csaky, 2019). Hargrave (2019) defined deep learning as a function of artificial intelligence that impersonates the mechanism of human intelligence in understanding and handling the information, and chatbot is an example of deep learning. Chatbot is one of the major areas of application for natural language processing (Shukla & Iriondo, 2020). Kohn (2020) claimed that a knowledge base centered on artificial intelligence (AI)

features can assist the users in an effective way to satisfy their requirements and chatbot is one of those features. Future researchers are strongly recommended to create an AI based knowledge base in the form of chatbot to help the requirement engineers, practitioners and field experts through the use of contiguous association among the areas, including knowledge base, natural language processing, deep learning and artificial intelligence. Particularly, the SWEBOK evolution team that is developing the public wiki for software engineering body of knowledge (V3, 2020) is requested to include the most powerful feature of online self-service depository in the form of chatbot, including the areas related to software engineering, elicitation of tacit knowledge, together with the outcomes of this study towards the detailed discussions of pre-interview agenda with the interviewees through electronic communication tools.

There are few studies offering the evidence of efficacy in elicitation methods for the elicitation of requirements towards software developments (Pachecho, Garcia & Reyes, 2018). Therefore, there is a need for detailed study of all the renowned elicitation techniques. Requirements elicitation techniques in Chapter 2 offered by Yousuf and Asger (2015), Malik et al. (2020) provide an adequate opening. The compilation of detailed studies including the results of this research should deliver the field specialists and academicians a comprehensive standard towards the effectiveness of these techniques.

The factors of software implementation failure are neglected in the existing literature and limited studies are available. However, implementation is an important phase where the software is unified with the workflow of the

organization. This is a paradigm that organizational change management is one of the major challenges in software implementation, required to be planned from the beginning because change management is a method where the stakeholders of the new implemented project move through a changeover from the current to a newly required position, according to the project deployment that is directly related with organizational culture.

Online interviewing is a fast growing method of elicitation where the interviewing is done through computer mediated communication (Dickson, Mavis, & Adu, 2020). This thesis has discussed the theme of 'Online Interviewing' in the section of literature review. Therefore, this theme might produce promising results, if integrated with the technique of detailed discussions of agenda before the process of interviewing through electronic communications.

Future researchers should consider following two recommendations:

1). Other combinations of electronic communication tools are required to be focused and implemented through the newly developed technique.

2). Implement these research steps for the elicitation of tacit knowledge for medium and large software developments.

5.4. Reliability and Prospects

The objectives of this research are clear and provides a strong base for further studies in future. This study was focused in gauging the usage and effects of electronic communications for the elicitation of tacit knowledge on experimental groups through the detailed discussions of pre-interview agenda with interviewees.

The subjects were from similar culture; therefore, this research has received reliable results at its maximum because of this cultural similarity. Future research can be conducted on diverse cultural backgrounds to test the effects of varied cultures on the elicitation of tacit knowledge through the use of electronic communication tools. Cultural difference impacts the capability of assertiveness that is the expressing competency of an individual to convey the thinking (Niikura, 1999; Lee & Bradley, 2002). Difference in cultural background might affect the practice of requirements elicitation at the preliminary and advanced stages (Mahraz, Benabbou, & Berrado, 2018; Sadig & Sahraoui, 2017).

This study is focused on the elicitation of tacit knowledge that leads to the development of small software. Costin (1980) and Rosato (2018) stated that all the processes should be completed through moving from small to medium and large projects because small projects are easy to handle and implement. There is a need of effective 'Requirements Engineering' practices for small, medium and large software developments to increase the rate of success (Basharat et al., 2013). Therefore, after receiving the positive outcomes of this state-of-art interview technique for elicitation, there is a need to examine the research for medium and large projects, to increase the rate of success.

5.5. Summary

Computers are used in railways, airports, banks, weather forecasting departments, communications and security systems. Their success is based on precise working of software systems. The process of software development starts with software

development life cycle, through the elicitation of requirements as the major phase that plays an important role towards the success of software. The rate of success for software projects in 2015 was 29%; however, failed or challenged projects were 71% (Standish, 2016). The cost of software failure in 2016 (for 548 investigated projects) was $1.1 trillion (Software, 2016). Monetary losses faced by software failure in 2017 (for 606 investigated projects) were $1.7 trillion (Scott, 2018). Moreover, the cost of software failure in 2019 for North America was $1.2 trillion that is considered as expected loss for each year (Undo, 2020).

Elicitation is a collection of detailed requirements (Collins, 2012; Cláudio et al., 2015). Collection of poor requirements is a continuous reason that leads to the failures of software (Davey & Parker, 2015; Gibbs, 2015; Expert, 2020).

During the process of requirements elicitation, gathering of knowledge could be unclear, hence, tacit and explicit are two terms to simplify the complexity (Casselman & Samson, 2005; Suryaatmaja et al., 2020). Explicit knowledge is easy to explain; however, tacit knowledge is the personal belief of an individual (Nonaka & Takeuchi, 1995). Elicitation of tacit knowledge is a challenging task (Sheposh, 2017).

Interviewing is as a tool of data collection that produces rich qualitative data (Mikene, Gaizauskaite, & Valaviciene, 2013). Interview technique is cited ineffective in the literature by Ho (2006), who had claimed that it is unable to handle the process of elicitation through interviewing, independently, and another elicitation technique needs to be integrated with the process of interviewing such as observation, to attain the effective outcomes.

This thesis has used electronic communication tools for the detailed discussions of pre-interview agenda with the interviewees. The concurrent triangulation design for mixed methods was used for the research. Two hypotheses were formulated through hypothetico-deductive method. The t-Test Paired Two Sample for Means was used to test the first hypothesis and One way Anova - Single factor was used to test the second hypothesis. Grounded theory was used to answer the research question through semi-structured interviews.

Total number of subjects was 120, divided into four equal electronic communication groups of 30 subjects for 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid'. Interview agenda was discussed in details before the meetings of interviews, for the duration of one month with the subjects of all groups.

Following four steps were used in the study with each electronic communication group:

1. Filling the questionnaires (Appendix C) before the use of e-tool.
2. Use of e-tool for detailed discussions of agenda.
3. Attending the interviews (Appendix D).
4. Filling the questionnaires (Appendix C) after the interviews.

First hypothesis was tested towards the effects of 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid', for following six key areas:

- 'Friendly' while using.
- 'Comfortable' while using.

- 'Essential' (part of interview technique).

- Help in 'Understanding' the requirements of the interview.

- Help in 'Learning' the requirements of the interview.

- Help in 'Elicitation of Tacit Knowledge'.

Results of the first hypothesis (for quantitative data 'Appendix C') were produced through t-Test paired two sample for Means.

Second hypothesis was tested for differences in effectiveness among four electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid') towards the above mentioned six key areas.

To answer the research question towards the differences of effectiveness among four electronic tools, interviews were conducted through semi-structured approach, for the elicitation of tacit knowledge (for qualitative data 'Appendix D'). The results of each experimental group was illustrated through 'Spider Chart' towards four factors ('General', 'Functionality', 'Usability', and 'Content'). The summary of interview was provided in tabulated form and a 'Comparison' chart was used to illustrate the percentage of prompting towards each electronic communication group.

The actual significance emerges from the results of this research validated that the use of electronic communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid' has positively affected the interview technique. Electronic communication tools have acted as moderating variables for the improvement of tacit knowledge elicitation process. Statistics have proved

significance towards the effects of these e-tools in the improvement of interview technique because the subjects of all e-groups acquired better understandings and learning towards the requirements of interview, confirmed the e-tools as comfortable and friendly in use. Moreover, this novel technique had helped the interviewer in better elicitation of tacit knowledge. Subjects counted the detailed discussions of pre-interview agenda through e-communications as essentials of the interviews. Moreover, the results revealed that there are differences in effectiveness among these four e-tools. Hence, the outcomes of interviews verified the effects of each e-tool in constructive direction. Prompting is a practice when the attention of an interviewee is pushed to the precise idea of inquiry, during the process of interview (Merriam-Webster, n.d.). According to the prompting results, 'Hybrid' (a combination of 'Audio Podcast' – *'Asynchronous' [one-way communications]* + *'*E-mail' – *'Asynchronous' [two-way communications]* + 'Online Chat Session' – *'Synchronous' [two-way communications])* e-tool was the best in minimizing the prompting effort with an overall 7% of prompting for the whole group. In addition, the overall percentage of prompting for the other e-tools was 27%, 40%, 70% towards 'Online Chat Session', 'E-mail', and 'Audio Podcast', respectively.

Therefore, overall it is proved through the quantitative and qualitative outcomes of this thesis that these electronic communication tools, including 'Audio Podcast', 'E-mail', 'Online Chat Session', and 'Hybrid' have positively effected the interview technique through the discussions of detailed pre-interview agenda with the interviewees.

Statistical significance, spider charts and percentage of prompting clearly verify that all the electronic communication tools have enriched the interview technique for the elicitation of tacit knowledge with positive differences in effectiveness. These electronic communication tools are proved as friendly, comfortable, and essential part of the interview process, helped in understanding and learning the interview requirements and helped in the elicitation of tacit knowledge.

Software Engineering Body of Knowledge (SWEBOK) is an international standard of knowledge collection for software engineering (Faq, 2020). Requirements elicitation for software requirements is done through requirements engineering (V3, 2020). Certainly, the results of this study will increase and enrich the elements of requirements engineering for 'SWEBOK'. Companies and organizations, those are using the interview techniques for the elicitation of requirements should give a great significance to the outcomes of this study.

This research provides primary evidence of its positive efficacy through the results of first and second hypotheses, and outcomes of research question. Moreover, this research strongly motivates to continue the future research towards the effectiveness of electronic communications on interview techniques. Further studies could be conducted, focusing on multi-cultural backgrounds, or implementation of this state-of-the-art technique for medium and large industrial projects.

The results of this research contributes to the body of knowledge as a fresh approach that is friendly and comfortable for the interviewees. The outcomes

deliver a set of electronic communication tools ('Audio Podcast', 'E-mail', 'Online Chat Session', 'Hybrid') that supports in developing a common vocabulary towards the process of interviewing, between the interviewers and interviewees. The results offer a set of electronic communication tools that helps in the elicitation of tacit knowledge, and helps in understanding and learning the interview requirements. Therefore, this technique would advance the existing method of interview, reduce the cost of development, save the time, and increase success of new software developments.

Field experts should decide the selection of electronic tool for communications depending on the feasibility of environment. 'Audio Podcast' communication is the easiest option because of its asynchronous one-way of communications. 'E-mail' is an easy mode because of its two-way asynchronous communications. 'Online Chat Session' is a two-way synchronous communications mode that needs real-time communications. 'Hybrid' is the combination of all these e-tools.

The future researchers have to answer many questions raised by this research such as the center of this research was the effectiveness of electronic communications on interview techniques; what could be the effects of electronic communications on other methods of elicitation for tacit knowledge?, what could be the impact of diverse culture on interviewing if integrated with electronic communications tools?, how much would be the impact of online interviews, if integrated with the steps of this research?, how would the other e-tools impact the interviewing technique after following the steps of this research such as video chatting, wikis, forums, audio e-

mails, blogs, and other blends?, how could the Computer Aided Software Engineering tools receive the benefits to enhance the effectiveness? These are common questions for the academicians and specialists to answer.

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Appendices

Appendix A

Approval of organization for research study.

Sultan Qaboos University

OFFICE OF THE ADVISOR
FOR ACADEMIC AFFAIRS

جامعة السلطان قابوس

مكتب المستشار
للشـؤون الأكاديميـة

4 February 2014

TO WHOM IT MAY CONCERN

This is to certify that the University has no objection of the Mr. Nauman Ahmad, IT lecturer from the Foundation Program, distributing the attached questionnaire and conducting some interviews to collect the relevant data for his research titled

"Effects of the Electronic Communication on the Elicitation of Tacit Knowledge on Interview Techniques for Small Software Developments "

Kindly cooperate with him to obtain the data required for his research.

for Dr. Taher Ba-Omar
VC's Advisor, Academic Affairs

Appendix B

Participant Acceptance Form with Study Details

Participant acceptance and details about the research study titled Effects of Electronic Communication on the Elicitation of Tacit Knowledge on Interview Techniques for Small Software Developments

Ref: CD/accept-os-pt
Main Researcher:
Nauman Ahmad
University of Huddersfield
Queensgate, Huddersfield
HD1 3DH, United Kingdom
Present Address:
Department of Computer Science
College of Science
PC123, Al-khoudh
Sultan Qaboos University
Sultanate of Oman.
E-mail: u1372027@hud.ac.uk, SQU: nauman@squ.edu.om

Information about research:
The aim of this study is to experimentally test the effects of electronic communications for the elicitation of tacit knowledge on interviewing through discussing the details of agenda with the interviewee, prior to the process of interviewing. The tacit knowledge elicitation is for gathering the requirements towards the provision of solutions for the production of software systems. The study will be conducted in the perspective of website development.

You have been recognized as a contributor/participant to contribute in this research study. Your task involves providing requirements for the development of software (course website) as interviewee. In this study you will go through the experiment process over the duration of one month. You will be requested to fill in two questionnaires, before and after using the electronic communication tools (podcast/E-mail/Chatting or Hybrid, depending on your group), and contribution in one interview. A survey questionnaire will take around 15 minutes to fill in. It is expected that the interview will not take more than 2 hours.

Advantages and Disadvantages to the Participant:
Research study will gather the data from the participant, and will not identify any of the participant. The gathered data will be focused on the elicitation of tacit knowledge from the participant as interviewee and will be used for the analysis and comparison purposes. The collected information will be grouped (combined) based on group analysis and it will not be possible to trace out the information related to any participant or individual.

Any participant will not be recognized through the elicited information of this study. Participant will participate in the interview for the purpose of eliciting the tacit knowledge. The extracted information will be grouped (combined) for analysis based on the electronic communication group, and finding out the information related to any individual or particular participant will not be possible.

There are no disadvantages related to this research. Your participation will be narrowed to filling in the two survey questionnaires, first questionnaire feedback will be before the use of electronic communication tool (related to your group) and second feedback will be after attending the semi-structured interview.
Your participation in the research will be significant and worthy to test the effectiveness of electronic communication tool. Your valuable time and devotion will help to get the results those could enrich the existing body of knowledge towards the area of tacit knowledge elicitation in requirements engineering. You will initially attend three lectures/sessions that will be delivered by the main researcher, to get an idea about the research project. These are no benefits or advantages.
In case of any query, please do not hesitate to contact Nauman Ahmad.

Information about Financial Benefits to the Participant:
You will not be paid for your participation in the research.

Privacy in research:
Participants will not be identified in this research. Your individual particulars will not be needed on the feedback surveys. All the data collected for this research is confidential.

Withdrawal of Participant from the research:
You are allowed to leave your contribution at any stage, and there will be no hindrance or disadvantage for doing so. If you decide to withdraw, the information collected from you will be saved for the length of research period and 3 years after.

Participant's Endorsement as Volunteer:
I have read the given participants acceptance form with study details, completely understand and acknowledge the information given in this form and voluntarily endorse to participate. I have been informed and replied all the queries related with the research study. I hereby accept my participation for this research.

Participant's Signature: _____ Date: _____

Appendix C (Ahmad, Dweib, & Lu, 2016; Ahmad, Lu, & Dweib, 2017)

QUESTIONNAIRE FORM *(for 'Before' interview and 'After' interview)*

Effect of the Electronic Communication on the Elicitation of Tacit Knowledge on Interview Techniques for Small Software Developments

<u>**Electronic Communication tool:**</u> Audio Podcast/E-mail/Online Chat Session/Hybrid

<u>**Please Tick**</u>

○ Male

○ Female

Dear Student:

The function and intention of this form is to obtain your opinion regarding the Electronic Communication tool used for interviewing (Audio Podcast/E-mail/Online Chat Session/Hybrid). Your input will help out in understanding the effects of electronic communication on the elicitation of tacit knowledge on interview techniques for small software development process and will not at all affect the evaluation of your work. Assess the following statements by selecting:

1	2	3	4	5	6	7	8	9	10

1=Strongly Disagree   **10=Strongly Agree**

Please encircle your answer;

Thanks for your help.

01.	I think Electronic Communication tool is friendly.	1 2 3 4 5 6 7 8 9 10
02.	I think Electronic Communication tool is comfortable, while using.	1 2 3 4 5 6 7 8 9 10
03.	I feel that Electronic Communication tool is an essential part of this interview.	1 2 3 4 5 6 7 8 9 10
04.	On the whole, Electronic Communication tool helps in understanding the interview requirements.	1 2 3 4 5 6 7 8 9 10
05.	On the whole, Electronic Communication tool helps in learning about the interview requirements.	1 2 3 4 5 6 7 8 9 10
06.	On the whole, Electronic Communication tool helps in the elicitation of tacit knowledge sharing process.	1 2 3 4 5 6 7 8 9 10
07.	I wish this interview to be conducted by the interviewer only.	1 2 3 4 5 6 7 8 9 10
08.	I wish this interview to be conducted by Interviewer and supported through Electronic Communication tool.	1 2 3 4 5 6 7 8 9 10
09.	I will recommend my friends, to the use of Electronic Communication tool for interviews	1 2 3 4 5 6 7 8 9 10
10.	I think the Electronic Communication tool is helpful in the collection of ideas in mind.	1 2 3 4 5 6 7 8 9 10
11.	I think the Electronic Communication tool is helpful in the organization of ideas in mind.	1 2 3 4 5 6 7 8 9 10
12.	I think the Electronic Communication tool is helpful in the presentation of ideas in mind.	1 2 3 4 5 6 7 8 9 10

Appendix D (Ahmad, Dweib, & Lu, 2016; Ahmad, Lu, & Dweib, 2017)

Requirements and Tacit Knowledge Elicitation:
One-on-One Semi-Structured Interview
Warm up questions:
Welcome to the interview, how are you…..etc.
Feel free to ask any question during interview……etc.
Note:
Further follow-up questions (Probing) will be asked, as appropriate, with each interviewee/participant to gain further response, and (Prompting) the pushing of participant in the right direction, as appropriate.
You may be asked to review your answer, if required, to add more clarity.
Questions about General, Functionality, Usability, and Content requirements and Tacit Knowledge Elicitation:

General Requirements:

1. Define the term WWW?
_____
_____
_____
_____
_____

For interviewer use only:
How would you rate the knowledge level of interviewee for the above mentioned Q#1 of interview (General Requirements) on a 5 point Likert scale?

| 1 | 2 | 3 | 4 | 5 |
---

2. Please explain what your problem statement is?
_____
_____
_____
_____

For interviewer use only:
How would you rate the knowledge level of interviewee for the above mentioned Q#2 of interview (General Requirements) on a 5 point Likert scale?

| 1 | 2 | 3 | 4 | 5 |
---

3. (a) Can you explain the role of interviewee (i.e. your role) for this interview?
_____
_____
_____
_____
_____

(b) Can you explain the role of interviewer (i.e. my role) for this interview?
_____
_____

_____
_____
_____

4. (a) List the name of Modules (or Components) you want to add to your educational website:

_____
_____
_____
_____

(b) Explain the existing Grading System, and your website requirements for the grading system:

_____
_____
_____
_____
_____
_____

5. What are your expectations from an educational web site?

_____
_____
_____
_____
_____

Functional Requirements:

6. Explain the difference between "Static Website" and "Dynamic Website":

_____
_____
_____
_____

7. (a) Which one of the following site fulfills your requirements?

☐   **Static site**

☐   **File based dynamic site**

☐   **Database driven dynamic site**

(b) Explain the detailed reason, why have you selected the above mentioned site format?

_____
_____
_____
_____
_____

8. Do you have any experience in using the above mentioned site format? Describe your overall experience, briefly.

_____
_____
_____
_____

9. Do you need to add User Interaction Feature to your educational website?

☐   **Yes**

☐   **No**

If Yes, explain the benefits of and impacts of this feature to your website:

_____
_____
_____
_____
_____

10. Do you have any other final thoughts or suggestions in terms of functional requirements of the website?

_____
_____
_____
_____
_____
_____

For interviewer use only:
How would you rate the knowledge level of interviewee for the above mentioned Q#10 of interview (Functional Requirements) on a 5 point Likert scale?

| 1 | 2 | 3 | 4 | 5 |

Usability Requirements:

11. (a) What is your requirement about font size and font spacing for your website?

_____
_____
_____
_____
_____
_____

(b) Would you like to share your experience about the impacts of font size and its spacing on a website?

_____
_____
_____
_____
_____
_____

For interviewer use only:
How would you rate the knowledge level of interviewee for the above mentioned Q#11 (a) of interview (Usability Requirements) on a 5 point Likert scale?

| 1 | 2 | 3 | 4 | 5 |

How would you rate the knowledge level of interviewee for the above mentioned Q#11 (b) of interview (Usability Requirements) on a 5 point Likert scale?

| 1 | 2 | 3 | 4 | 5 |

---

12. (a) What kind of overall format, you want to have for your website?
o   **Consistent**
o   **Inconsistent**
(b) How do you explain the role of your choice (Consistent or Inconsistent) in the performance of a website?

_____
_____
_____
_____
_____

13. What is your requirement about the load time of the home page of your website?
o   **Long time**
o   **Short time**
Explain why?

_____
_____
_____
_____
_____

14. What do you think about the impact of the text-to-background contrast?

_____
_____
_____
_____

15. What are the other special features in terms of usability, would you like to add to your course website?

_____
_____
_____
_____

Content Requirements

16. Explain, the term 'FAQ':

_____
_____
_____

17. How do you explain the importance of 'FAQ' for your website?

_____
_____
_____
_____
_____

18. State the requirements of important contents you want to have in your website?

_____
_____
_____

19. State the format of the documents (files) along with their extensions you want to see in your website:

_____
_____
_____
_____

20. Anything else would you like to say, to be added as content requirements to your course website?

_____
_____
_____
_____

Many thanks for your contribution in this interview.

Overall interviewer's observations and opinions about the interview:

_____

_____

_____

_____

_____

_____

-    Overall prompting was done for this participant, during the interview: ☐ Yes   ☐ No