

The Design of Adaptive Acquisition of Users Feedback: an Empirical Study

Malik Almaliki, Cornelius Ncube and Raian Ali
Faculty of Science and Technology
Bournemouth University, UK
{malmaliki, cncube, rali}@bournemouth.ac.uk

Abstract— Users’ feedback is a main source of knowledge on how users perceive the role of software in meeting their requirements. Collectively, such feedback helps shaping software autonomous and semi-autonomous adaptation decisions of what is called Social Adaptation. It also helps developers to identify loci in the system where an evolution should be introduced in the next release. Despite this role of users’ feedback, there is a lack of systematic engineering approaches on how to design its acquisition mechanisms. In this paper, we observe that the acquisition of feedback should be itself adaptive to the context of use. We conduct an empirical study following a mixed-method sequential exploratory approach to explore the main drivers of such adaptation and understand users’ attitude when being asked to provide feedback. Our findings are meant to enrich the knowledge base for developers and researchers in users-centric, or crowd-centric, adaptation. It also highlights areas of study for a future research in the area.

Keywords— *User Feedback; Requirements; Social Adaptation*

I. INTRODUCTION

Traditionally, the research in engineering adaptive systems has deliberately limited the role of users in steering the adaptation process with the good intention of maximizing the system’s autonomy and minimizing the need for human’s intervention. There has been a great deal of emphasis on architectures to support design and development of adaptation, models for anticipating and reacting to changes in the managed system and methods for verifying properties of these systems [2, 7]. Ultimately, self adaptivity is a meta-computing capability which enables a system to reason about itself and its dynamic environment so that it can formulate the right decisions to reach users’ requirements [5]. Thus, users and their requirements are main drivers for adaptation.

Overlooking the role of users in forming adaptation decisions and the reliance on software developers and design-time validation, steered by developers, would lead to adaptation decisions that eventually and sometimes very quickly, become invalid. To keep the software up-to-date with regards to users’ needs, users should be given a voice in shaping adaptation as a lifelong process [1]. Giving users an active role makes adaptation more transparent and increases their confidence in the system [6]. In this direction, one of the

research challenges identified in the engineering of self-adaptive software systems road map is: [To devise a way of] “*analysing feedback types from human-computer interaction and devising novel mechanisms for exposing the control loops to the users, keeping the users of self-adapting systems in the loop to ensure their trust*” [2].

Users can collectively enrich the adaptation decision making ability. Social Adaptation is defined as a system’s autonomous ability to analyse users’ feedback and choose an alternative configuration which is collectively shown to be the best for meeting requirements in a context [1]. Social Adaptation has the benefit of keeping the software and developers’ knowledge about users updated. Since users are treated as first-class entities in both the engineering and also the operation of such systems, Social Adaptation is also expected to improve transparency and raise user trust in self-adaptive systems. In fact, over a long time using the software, users may be able to shape the decision-making process in a way that can only be done by today’s experts.

Research on the role of users and their requirements in self-adaptive systems have been done under themes such as requirement-aware self-adaptive systems [8], requirement monitoring at run-time [5], users’ involvement in software evolution [12] and adaptation in pervasive software systems [4]. Social Adaptation is unique in the sense that instead of catering to the requirements of a user or subset of users, it harnesses the wisdom of the “crowd” to adapt the system rather than the decisions of an elite group of users or those of developers. Social Adaptation pursues the goal of democratic-like, consensus-based social approach to adapting software systems to meet users’ requirements.

A core element of involving users in the adaptation process is that their feedback is obtained while using the software in different contexts. The lack of engineering processes for feedback acquisition leads to poorly designed feedback collection mechanisms and this in turn harms the quality of collected feedback, users’ experience and the quality of adaptation and evolution decisions [10]. Despite of this role of users’ feedback, there is a lack of research on how to engineer feedback acquisition in a way that guarantees quality of the obtained information and, the same time, maintains user’s experience.

In this paper, we conduct an empirical study to understand users’ different perspectives and behavioural aspects to feedback acquisition for socially-adaptive software. A mixed

method (sequential-exploratory approach), consisting of interviews and a questionnaire, was followed. Our findings show that the acquisition of feedback is best designed as an adaptive process itself. We elaborate on a set of important factors which should be catered for when designing that adaptation. Our findings contribute to the knowledge base for developers and researchers on tackling the diverse challenges of a systematic development of feedback acquisition for the user centric, or crowd-centric, adaptation.

The paper is structured as follows. In Section 2 we describe the design of the qualitative phase of the study. In Section 3 we discuss the results of that initial qualitative phase. In Section 4 we describe the design of the quantitative phase of the study and we report on the results in Section 5. In Section 6 we elaborate on our findings. We discuss the threats to validity of our study in Section 7. In Section 8 we review the related work and in Section 9 we draw our conclusions and recommendations for designing an adaptive feedback acquisition.

II. QUALITATIVE PHASE DESIGN

Qualitative methods have been shown to be helpful in studying and gaining deep and better understanding of human behaviour [16]. Since understanding the behaviour of users in relation to feedback acquisition in software applications is a high concern for us, the qualitative phase is a good fit to adopt as a first phase in our methodology. This allows us to get enough insights on users' behaviour to feedback acquisition in order to develop the second phase of our methodology.

Interview is one of the common methods of data collection in qualitative research [17]. Interviewing can be distinguished from other qualitative data collection techniques in that it is much more exploratory in nature and much more flexible in location, scheduling and range of participants. It is also a very effective method for gaining a deep insights and understanding of other's behaviour [18]. For the previous reasons and the nature of our study which aims to understand people's behaviour and perceptions with regards to feedback acquisition in software applications, we adopted interviews as a data collection method in the first qualitative phase. This qualitative phase will guide our development of the second phase, the quantitative phase.

A. Interview Design

Semi-structured interviews were conducted with 7 participants to explore their perception of software-mediated feedback acquisition. Participants were carefully selected in order to guarantee a high level of diversity and to avoid bias towards only certain group of people (e.g. different personal characteristic). These face-to-face interviews were conducted at Bournemouth University and each interview lasted for about 40 minutes.

An interview protocol was developed in consultation with the literature [19] and the results of a group discussion which followed a research seminar given by the authors on the topic. The protocol was revised after 2 initial pilot interviews. In the protocol, the first set of questions (personal information) was developed to ensure diversity in participants' personal

characteristics. The second set of questions (general software and computer familiarity) was developed to ensure that participants are familiar with software applications and computers in general and to ensure that the inclusion criteria are fully met by all participants. The last set of questions (experiences and behaviours) was developed to study participants' perception and attitude with regard to software-mediated feedback acquisition. The interview script can be found at: <http://goo.gl/4NPg1H>. By combining the interviewees' answers, we were able to draw foundations and develop a solid base that helped us in the design of our second quantitative phase of the study. At the beginning of each interview session, each participant signed a consent form.. In addition, each participant received £7 lunch voucher as an appreciation for taking part in our study.

B. Sampling

Purposeful sampling is a common technique in qualitative research [19]. In this study, we used purposeful sampling to select candidate participants to be interviewed. Our inclusion criteria allowed for participants who are either students or university staff members coming from different backgrounds, within an age range of 19 to 29 and average computer users (various use of software applications, e.g. internet browsing). The sampling criteria were developed to allow for more accuracy and variety in selecting participants. In addition, we targeted the academia sector due to easy access to academic participants in different academic institutions all over the world. This geographical diversity enhances our study by gathering different perceptions and opinions regarding feedback acquisition in software applications.

In qualitative research there is typically no emphasis on the quantity of participants and the number of participants depends on reaching a saturation point. This means the sampling of relevant cases should continue until no new theoretical insights are being gathered from the data [20]. In our research we interviewed 7 participants till we reached a reasonable saturation in terms of getting insights that allowed us to develop our second quantitative phase. Table 1, shows the characteristics of our sample.

TABLE 1 THE CHARACTERISTICS OF THE INTERVIEWEES

Participants	Age	Gender	Education Level	Home Country
P1	19	Male	Undergraduate	UK
P2	29	Male	Postgraduate	Nigeria
P3	24	Female	Postgraduate	Nigeria
P4	19	Female	Undergraduate	KSA
P5	23	Male	Undergraduate	UK
P6	28	Male	Undergraduate	USA
P7	26	Female	Postgraduate	KSA

C. Analysis

Interviews were audio taped and transcribed verbatim. Analysis was performed in several steps which included: (1) initial exploration of the gathered data by reading the transcripts; (2) coding data by labelling and segmenting the text; (3) using an inter-coder agreement check to verify codes (two researchers worked on verifying codes and a third researcher was approached for solving conflicts); (4) using

codes to generate themes by gathering similar codes together; (5) connecting, comparing and interrelating themes. Credibility of our findings was maximized by the inter-coder agreement and academic advisor’s auditing [19, 21].

III. QUALITATIVE FINDINGS

As previously stated, the interview design covered different angles of user behaviour with regard to feedback acquisition in software applications. When analysing the data by grouping like-minded (similar in meaning or context) quotations, 31 codes and sub-codes began to emerge which were further grouped into 6 themes. Table 2 shows the themes, codes and sub-codes. Each theme consists of two or more codes/sub-codes which are briefly discussed and illustrated further with interview excerpts:

TABLE 2 A BREAKDOWN OF THE THEMES, CODES AND SUB-CODES

<p>Theme1: Explicit Feedback Advantages [1.1] Evident channel for delivering users’ voice and raising developers’ awareness [1.2] Better for ethical reasons</p>
<p>Theme2: Motivation for Accepting/Ignoring Feedback Requests [2.1] Visibility of feedback effect on the system [2.2] Usability and simplicity: o Language used [2.3] Disagreement of existing feedback [2.4] Reasonable number of feedback requests [2.5] The exciting nature of feedback subject [2.6] Positive experience [2.7] Negative experience and needs for improvement [2.8] Less interruption and distraction [2.9] Device used [2.10] Raising public awareness [2.11] Being forced by the software: o Low quality feedback</p>
<p>Theme3: Feedback Acquisition Methods [3.1] Email is preferable: o More personalized o More preferable for qualitative feedback o More time space and less interruption o Reasonable number of feedback requests [3.2] Passive feedback forms are preferable [3.3] Quantitative feedback request is preferable [3.4] Combination of qualitative and quantitative (not only quantitative)</p>
<p>Theme4: Pause of Feedback Requests [4.1] Same feedback is given [4.2] Lack of interest [4.3] Passive feedback is preferable</p>
<p>Theme5: Timing for Feedback Requests [5.1] Enough time before requesting feedback [5.2] On recent service or product [5.3] Reminder is needed [5.4] Avoid work time or hours</p>
<p>Theme6: Feedback Visibility [6.1] Ability to see what others said [6.2] The trend of current feedback</p>

A. Explicit Feedback Advantages

Participants were asked about the value and advantages of being explicitly asked for feedback. The majority of participants emphasized two different aspects as the core advantages of explicit feedback:

- [1.1] Evident channel for delivering users’ voice and raising developers’ awareness *“Explicit feedback would be a lot better. That’s why most people that release software go to conferences and tell software programmers, game reviewers, and different people to talk about the software they produce”*.
- [1.2] Better for ethical reasons *“I think from an ethical standpoint, explicit feedback is much friendlier to a user because they know exactly what they’re submitting”*.

B. Motivations for Feedback Provision

The past experiences of the interviewees with feedback requests enabled them to identify the factors that have a noticeable effect on their motivations to give feedback on a software service or a product. The following dimensions of motivations were extracted from participants’ responses:

- [2.1] Visibility of feedback effect on the system.

Some participants indicated that being able to see the impact of their feedback on the software plays a core role in motivating them to give feedback *“The problem that I always have when I’m asked for feedback is; does my feedback really count?”*

- [2.2] Usability and simplicity

Another factor that motivates users to give feedback is the simplicity, and usability of the method and the language used to get their feedback *“why do I have to give a four paragraphs of feedback on a product when I can just rate or rank it”, “I think it is all about the word you use versus a word that might intrigue people”*.

- [2.3] Visibility of opposite feedback

An interesting factor that can increase users’ motivations to provide feedback is the user’s ability to see different types of feedback that conflict with their own perception or opinion about a product or a service provided by a software application *“If negative feedback is given for example by a seller on eBay and I had positive experience with them then Yes I would give feedback to I could warn people that there’s a chance that you might like this seller”*.

- [2.4] Reasonable number of feedback requests

Receiving a large number of feedback requests might lower users’ motivation to respond to feedback requests due to the annoyance that it typically causes *“I think receiving emails all the time asking for feedback is quite bothersome because you’re getting loads of emails in your inbox”*.

- [2.5] The exciting nature of feedback subject.

Being obsessed or passionate about a product or software service plays a role in motivating some users to give feedback or write a review about it *“I give feedback on things that make me happy. But when it’s just like gloves and shoes and regular things, I don’t even do that”*.

- [2.6] Positive experience

Being significantly happy and satisfied with a product or a software service greatly increases users motivation to review or give feedback about it *“I bought a cooling pad for my processor and I wrote a couple of things, but not so much so I just wrote that like how it came really quickly and it was really good, it fits perfectly, it’s cheap.”*.

- [2.7] Negative experience

Interestingly all respondents agreed that being unhappy, unsatisfied or in need for improvements with a product or software service is a key factor that drives them to give feedback about such as raising complaints *“On eBay when I didn’t get my item in the end I had to leave a negative feedback”*.

- [2.8] Less interruption and distraction

“I wouldn’t suggest anyone to pop up into my window when I’m busy doing some work. It is just an offense”.

- [2.9] Device used

“If you ask me for a feedback that requires me to write many sentences while using my smartphone then surely I won’t reply. But if I was using my pc then I might respond”.

- [2.10] Raising public awareness

“The reason I gave feedback was because I wanted to make sure that everyone learns about this specific service and its negative and positive sides”.

- [2.11] Being forced by the software

An observation was made by many respondents on being forced by the software to give feedback (e.g. popup dialogs) as a motivation to respond to these requests *“it’s just a kind of gentle way to force me to give feedback”*. However, being forced to give feedback can cause a low quality feedback *“I would give a low rating from the frustration or high rating just to get it away from me”*.

C. Feedback Acquisition Methods

Participants were asked to recall some of their past experiences with regard to feedback acquisition and their reaction to it in order to extract their preferred method. Various methods were extracted from their responses:

- [3.1] Email

Emails give more time for users to respond to feedback requests as well as less interruption. They are also better for qualitative feedback *“I think emails are good if you want someone to actually sit down and write a couple of sentences about how they feel about your service”*. Emails are also more personalized *“If you say something that is meant to be only for me such as asking me by my name then I would responds, why not?”*

- [3.2] Quantitative feedback request

“I prefer multiple choice or ratings because it’s just easier, simpler, and faster”.

- [3.3] Passive feedback forms

We define passive feedback as a feedback that is given by the user on voluntary bases and without being asked to do so by the software. An example can be a rating panel to the left side of a website page. One participant indicated that having feedback requests sent to them by all means (i.e. emails, popups) is annoying and a feedback channel to deliver their

voice when needed should be passively available (e.g. feedback form in a website) *“I find it problematic to send me any kind of feedback requests. If I’m not happy with something I will go to their website and complain right to them”*.

- [3.4] Combination of qualitative and quantitative

“In the real world, the best way is to sort of have a combination of both qualitative and quantitative “Rate and then If you have any other comments, please leave them below”.

D. Pause of Feedback Requests

From participants’ responses we created this theme that encapsulates the dimensions in which sending or asking for feedback should be paused or stopped:

- [4.1] Same feedback is given

When the same feedback or response is given by the user (i.e. same rating each time) *“I’ve done it like once or twice but it usually comes up a lot. It just keeps popping up. If I keep sending them the same answer then there would be no point of asking again”*.

- [4.2] Lack of interest

When there is an ignorance or lack of users’ interest in the software service or product *“I find it annoying is when I’m using my phone and I do not really care to rate an application and it keeps saying; will you please rate this application?”*

- [4.3] Passive feedback is preferable

When users do not prefer to be directly asked for feedback and would rather give feedback when they want.

E. Timing for Feedback

All participants indicated that timing for sending feedback requests is a critical factor that can affect their response to the requests. Participants indicated some timing factors that should be taken into account when initiating a feedback request by software:

- [5.1] Enough time before requesting feedback

Enough time should be given to the users to familiarise them with the service or product before asking for feedback in order to maximise the quality and truthiness of the feedback *“I think a user needs some time to really get a good evaluation of what they’re using before they are asked for feedback”*.

- [5.2] On recent service or product

Feedback should be requested on a product or a service that the user has used recently so that the user is still interested in it and find some excitement in expressing their opinion.

- [5.3] Reminder is needed

Some users need to be reminded to respond to feedback requests *“I don’t delete feedback emails so that I’ll remember to come back to it but sometimes I kind of forget to come back”*.

- [5.4] Avoid work time or hours

Asking for feedback when users are busy might affect their willingness to respond to these requests *“I wouldn’t expect myself to probably send a feedback during working hours”*.

F. Feedback Visibility for Decision Making

- [6.1] Ability to see what others said

Being able to see others feedback and reviews is a positive mechanism that affects users' perception about certain software service or a product.

- [6.2] The trend of current feedback

Visibility of others feedback/reviews could also motivate users to give feedback or write a review about the provided service.

Some of the themes explained above are interrelated with each other. For example, being motivated to give feedback and being targeted by the wrong feedback acquisition method makes users lose interest in responding. Another example is that, being motivated and targeted by the right acquisition method but at the wrong time makes users ignore responding to the feedback request and vice versa.

The interviewees described their behaviour and past experiences with regard to feedback acquisition in software applications. Analysing the qualitative data resulted in six dominant themes. We used the six themes/dimensions as a foundation for developing a quantitative measure. The next section describes the process used for developing, conducting, analysing and reporting the second phase of the study.

IV. QUANTITATIVE PHASE DESIGN

The aim of the quantitative phase is to combine the unique strengths of both qualitative and quantitative paradigms to further investigate and assess our findings from the first phase and allow for more generalizability. For this phase, a questionnaire with 31 questions with various types (i.e. single choice and multiple choice questions) was developed. Findings from the qualitative study served as the bases for developing the survey's script with regard to users' perception and reaction to feedback requests.

The questionnaire was first piloted on six participants who met our sampling criteria. The feedback from those participants was used to revise and refine the questionnaire before distributing it to the larger sample of participants. The revised and refined questionnaire was then sent by email to selected students and staff members. The invitation email contained a brief description of the purpose of the questionnaire and asking them to take part in the study. The e-mail also contained a web link to the questionnaire and instructions for accessing it. The questionnaire itself started with an introduction to the topic of interest so as to familiarize the participants with the subject matter. Participants were also informed about what is expected from them and how the

results of the questionnaires will be used. The data collection took place between September 15 and November 16, 2013. Five days after distributing the questionnaire, e-mail reminders were sent to participants who did not respond to the invitation. The questionnaire and data gathering went through the ethics approval process. The questionnaire submitted to participants can be found at: <http://goo.gl/4NPg1H>.

A. Sampling

A simple random sampling approach was used as to recruit the participants. The advantage of the *simple random sampling* method is that it minimizes bias in selecting participants and allows the result to be more generalizable to other populations groups [22].

Access to students and staff members email contacts at Bournemouth University was gained by the university and a computer software program was used to generate and extract a random set of emails and mailing lists that was then used as a selected sample.

In order to counter-balance the geographic and demographic homogeneity of the on-campus participants, a convenience sampling technique was also used to recruit more participants (35) from different countries such as Egypt, KSA, Ireland, China and the Netherlands. Table 3 shows the characteristics of the participants.

A total of 180 participants were invited to take part in the survey. A number of 150 participants started the survey and 100 appropriately completed forms were returned. When considering the average time to complete the survey (25 minutes), the size of the form and the amount of effort required completing it, we consider this number of participants to be a good rate of return. We closed the survey once we reached 100 participants. We considered this as a reasonable number of responses especially that the initial analysis of participants responses at that stage showed that some clear trends and clusters were already established.

B. Analysis

The returned questionnaires were analysed and cleaned up and irrelevant and inconsistent responses were excluded (i.e. 50 incomplete and/or clearly random forms were excluded from the analysis). A statistical analysis of the survey was conducted to describe the data [23]. Then a cluster analysis was conducted to group similar users into initial clusters according to their behaviour to feedback acquisition in

TABLE 3 PARTICIPANTS' DEMOGRAPHIC INFORMATION

		Age Range				Gender			
		18-25	26-34	35-54	55-64	Total	Male	Female	Total
level of education	High school	3	0	0	0	3	3	0	3
	Bachelor's degree	9	3	6	0	18	13	5	18
	Master's degree	6	36	10	3	55	30	25	55
	Professional degree	0	0	1	1	2	1	1	2
	Doctorate degree	3	11	5	0	19	10	9	19
	Others	0	3	0	0	3	2	1	3
	Total	21	53	22	4	100	59	41	100

software applications. The statistical analysis was carried out using Qualtrics (www.qualtrics.com) which is a widely used online survey software. The cluster analysis was conducted using Weka tool [26]. Weka is a data mining tool that is widely used, free, open source Java application. It provides algorithms and computational paradigms that allow computers to discover structure in databases and perform predictions.

V. QUANTITATIVE FINDINGS

A. Participants' Characteristics

The participants' demographics were analysed using cross tabulation and frequency counts and then summarized. Participants were compared over their age, gender, level of education and country. From this analysis a high level of diversity among participants is clearly presented maximizing the generalizability of our findings. For example, participants come from 19 different countries including UK, KSA, Brazil, Iran, Germany, and USA. They had different ages, genders and levels of education as shown in Table 3.

In addition and as shown in Table 4 and Table 5, the majority of the participants represent a typical set of software users who use typical and diverse set of popular software applications rather than domain specific software (e.g. desktop applications) for everyday life activities (e.g. movie players). Therefore, their feedback reflects their experience with popularly used software applications. This supports the generalizability of our finding.

TABLE 4 THE TYPE OF SOFTWARE FREQUENTLY USED BY THE PARTICIPANTS

Software Applications	Usage Rate
Desktop Applications such as MS Office, Movie Players, etc.	94%
E-commerce such as Ebay and Amazon, Online Shopping, etc.	73%
Mobile Apps: applications installed on your mobile	84%
Search Engines such as Google, Skyscanner for flights and Venere and Booking for hotel reservation, etc.	92%
Social Networking such as Facebook, Twitter, Wikis as an editor, etc.	81%
Web Applications such as online documents editors like Google Doc, online calendars, storage services like DropBox, etc.	80%

TABLE 5 THE TYPE OF ACTIVITIES SOFTWARE APPLICATIONS FREQUENTLY USED FOR.

Activities Performed	Usage Rate
For professional reasons: their work requires that	63%
For academic reasons: their study/research requires that	84%
Daily life activities (booking, online shopping, looking for bus schedule, taxi number, etc.)	86%
Entertainment (gaming, social networks for entertainment purposes, etc.)	64%
For social interaction (social networks, blogs, forums, etc.)	75%

B. Feedback Acquisition Methods and Feedback Types

Before digging deeper into users' preferences in regard to the methods that have been used to collect their feedback, we investigated whether they actually like to be asked for feedback explicitly. 70% of the participants provided negative responses. This reflects the high need for novel mechanisms to

increase users' engagement as evaluators of software applications. This also provides strong evidence that the current explicit feedback acquisition processes are poorly engineered and conducted. This suggests that new novel mechanisms and engineering approaches are needed to change users' negative views toward feedback acquisition. Some comments from participants further explain the logic and motivation behind their negative views (see Table 6):

TABLE 6 SAMPLES OF USERS' COMMENTS ON FEEDBACK REQUESTS

Users Comments
"I find it hindering and unprofessional."
"They often ask several times about the same thing."
"The benefits are always not clear to me as a user."

Participants were further asked to choose their preferred types of feedback and methods used for gathering such feedback. A number of answers were extracted from their responses which highly confirm and enhance our previous findings in the first phase of this study (see qualitative findings). Participants' answers vary over the following items:

1. Feedback Types

Explicit feedback: such as sending emails to users asking their feedback. Explicit feedback includes:

- **Qualitative feedback** which is preferred by 9% of participants. An example of this type would be writing sentences or lines of texts to communicate users' thoughts in a free-style.
- **Quantitative feedback** which is preferred by 48% of the participants. An example of this type would be rating and giving stars to a set of quality attributes such as comfort, and speed.
- **A combination of qualitative and quantitative** which is preferred by 55% of the participants. This means the user has the choice to use their preferred one such as rating and giving stars with the ability to add text if I need.

Implicit feedback: such as monitoring and analysing users' usage of the software application. Participants showed less interest in implicit feedback. Only less than 20% choose implicit feedback as their preferred method. Privacy issues and ethical related factors could be the reason behind this low interest. For example, a user commented that "*The implicit modality is also interesting, but I tend to be concerned with my privacy and disallow this option*".

2. Acquisition Methods

- **Passive feedback acquisition** method is preferred by 51% of participants. In this method users submit their feedback on a voluntarily base and without being proactively asked by the software (i.e. through a contact us form).
- **Offline feedback acquisition** method is preferred by 33% of the participants. In this method users submit their feedback offline (i.e. after using the software). An example of this method would be sending the user

an email or an SMS message asking for their feedback.

- **Online feedback acquisition** method is preferred by 54% of the participants. In this method users provide their feedback online while using the software. An example of this method could be showing the user a feedback popup dialogue while using the software.
- **Using Hints or tips** as a method to collect users' feedback is preferred by 31% of the participants. An example would be showing a user a hint message telling the users that they can go to a feedback centre such as a forum specifically designed for this purpose and leave their feedback.

Table 7 shows some comments from the participants to further explain their logic and motivation of their choices:

TABLE 7 USERS' COMMENTS ON FEEDBACK ACQUISITION METHODS.

Users Comments
<i>"Definitely online, real-time sounds ok, but this really depends on what I am doing and how much time I have to be altruistic."</i>
<i>"I prefer 'pull' over 'push' - emails etc I can pull when it's convenient; popups and other 'push' mechanisms intrude & interrupt flow."</i>
<i>"I hate popups. I prefer seeing noticeable small box somewhere I can see on the website asking me to leave a feedback."</i>

C. Motivations for Accepting/Ignoring Feedback Requests

Further analysis of the participants' responses extracted the following dimensions of motivations which highly enhance and confirm our previous findings (see qualitative findings):

1) Users' Experience

The first set of motivations that were identified by users is related to users' experience with feedback requests that can negatively or positively affect their willingness to respond to a feedback requests. Users' responses varied over the following factors:

- **Simplicity of feedback requests** was indicated by 64% of the participants as a key factor that can highly influence their willingness to give feedback. An example of this factor could be the time a feedback request requires a user to think about and answer.
- **Timing for feedback requests** was also indicated by 75% of the participants as a vital factor that can greatly affect their willingness to give feedback. For instance, when a user is engaging with some other activity they may not respond.
- **Awareness of the usage and impact of the feedback on the system** was mentioned by 54% of the participants as a valuable factor in motivating them to give feedback. Users can be motivated to give feedback if they are able to know how their feedback would be used and whether it has been taken into account to improve their experience or led to any changes.
- **Privacy** is also a factor that can affect the willingness of around 31% of the participants. An example of a privacy factor that can decrease a user' willingness to give feedback could be the ability of others to see or infer the user's given feedback.

- **Familiarity** with the software was also indicated by 42% of the participants as an important factor that can affect their willingness to give feedback. For instance, users are more motivated when they have enough experience with the software application before responding to feedback requests.

Users find it against their privacy to use their implicit feedback (see qualitative findings: explicit feedback advantages). However, in comparison to other factors for motivating users to give feedback (i.e. simplicity of feedback requests), privacy issues do not seem to play a highly important role in motivating users to respond to explicit feedback invitations as indicated by the low percentage given by users to privacy reasons (31%). Timing for feedback request has been also highly emphasized by both users and experts as discussed in [3] to be a highly important factor that can negatively or positively affect users' willingness as well as the quality of their feedback. Table 8 present participants' responses when asked the following question:

"How do you feel about the feedback requests which come at the wrong time (a popup dialogue when you are navigating a website and moving to another page, a hint in a YouTube video to encourage you to rate it)?"

TABLE 8 USERS' ANSWERS IN REGARD TO WRONGLY TIMED FEEDBACK REQUESTS.

Answers	Percentage
Are OK with me	7%
I think this is one of the ways which puts a gentle pressure on me so that I give feedback	11%
Decrease my willingness to give feedback	58%
I may give less truthful feedback just to get rid of the dialogue	26%
I believe it is an inconsiderate way to force me to give feedback	43%

2) Interface Design

Users emphasized the impact that interface design has on their behaviour and willingness to give feedback. The interface design can easily increase or decrease users' willingness to respond to feedback requests. It can also positively or negatively affect the quality of the feedback as discussed in [3]. Users' responses varied on the following design factors:

- **Language used** in the feedback request (i.e. friendliness, succinctness and clarity) was indicated by 52% of the respondents as a design factor that can influence their willingness to give feedback. This reflects the need and importance of carefully wording feedback requests and selecting the right language that fits the context of use and the type of users - e.g. formal language might be more suitable for professional users.
- **Graphical design** of the feedback request (i.e. font size, colours and the kind of photos used in the acquisition interface) was also indicated by 31% of the respondents as a design factor that plays a modest role in motivating them to give feedback. The low percentage reflects users' need for simple and straightforward feedback requests that are not full of graphically complicated presentations. However, this does not exclude the need for feedback

requests that are graphically displayed in an attractive and reasonable way (e.g. readable font size).

- **Simplicity and complexity** degree of the method used to provide the feedback (i.e. clicking, a voice message, text with/without auto-completion) was mentioned by 74% of the participants as a factor that plays a vital role in motivating them to give feedback. The high percentage highlights the fact that users always avoid spending too much time and effort responding to feedback requests that require too much time and effort to submit their input. This reflects the importance of keeping feedback request processes and interfaces simple and straightforward as much as possible to leverage users' response rate and the quality of feedback
- **Fitness of the design and content** of feedback request to the context of use is a significant factor that can greatly influence users' willingness to give feedback as indicated by 81% of the respondents. Example of such a factor could be - showing less details and simpler content when the user is using a smartphone. The relatively high percentage reflects users' frustration about feedback requests that do not take the context of use into consideration - e.g. presenting a complex and detailed feedback interface when the user is using a smartphone. This also indicates the importance of the context of use in relation to the interface design of user feedback requests.
- **Information provided** is considered as a modest factor that can also affect users' willingness to give feedback as mentioned by 24% of the participants. Example of such a factor could be showing users a summary or statistics of other people's given feedback. Although the information provided by the feedback request interface is not highly important for some users, it is still considered by some users as an encouraging factor to respond to feedback requests. A dynamic feedback interface that shows a runtime statistics and summaries of feedback already given on a certain aspect of the software is still a valuable interface design factor that can empower user response rate and satisfaction.

3) Social Factors

Almost half of the participants indicated that several social factors, when considered in feedback acquisition, can noticeably affect their willingness to give feedback and their level of engagement with the software application. The following factors were emphasized:

- **Visibility and similarity of others feedback:** 47% of the participants indicated that being able to see others feedback and compare it against their own opinion about a service or a product can greatly affect their willingness to give feedback. For example, the majority of participants indicated that being able to see other people's feedback first and then compare it against their own opinion and having the option to accept or reject to give feedback can encourage them to give feedback. A user commented: *"Giving feedback is a community experience and it helps to feel among others"*. However, the rest of participants indicated that visibility and similarity of others feedback

will have no effect on their willingness to give feedback by all means.

- **Volume of already given feedback:** 52% of the participants indicated that the volume of already provided feedback on service or a product can affect their willingness to give feedback. For example, participants' willingness to give feedback increases when there are only few people who provided feedback on a service or a product. The remainder indicated that the volume of already given feedback has no effect on their willingness to give feedback by all means.
- **Social recognition:** 57% of the participants indicated that being socially recognized as a feedback provider is an important factor that can increase their willingness to give feedback and engage more with the software application. There could be some constraints on this though. For example, some participants emphasized that, it is nice to be visible only when others can see their feedback which led to some changes on the system. The rest of the participants indicated that social recognition has no effect on their willingness to give feedback by all means. This could be due to privacy reasons as some users commented *"I don't like others in my social network to see my feedback. I want to remain anonymous"*, *"I am less likely to leave feedback if I am easily identifiable"*.
- **Feedback acquisition as a social activity:** 63% of the participants indicated that feedback acquisition as a social or game activity is not an important factor that affects their willingness to give feedback. Example of such an activity could be the users' ability to visualize how their direct and indirect social contacts are rating a certain service and how their feedback influenced the trend in their community. This negative response could be due to the desire for simplicity of feedback acquisition process. For example, a user commented: *"I would generally say No. If I want to give a feedback, it would be feedback alone. I usually don't want any continuation from there."*

However, the rest of the participants showed a positive interest in such an activity and even suggested some ideas on how to conduct the feedback acquisition as a social or game activity. A user commented: *"maybe a chat feedback dialog box would be nice (sending the feedback live and looking at different users sending feedback at the same time). I do not like it to be more complicated or time consuming."*

The previously mentioned factors provide a clear vision about the conflicts and variety among users' behaviours and preferences with regard to feedback acquisition and the related social factors. This highlights the need to have a systematic way to develop such an activity that fits all different behaviours and preferences of users.

4) Volume and Frequency of Feedback Requests

Participants indicated that if the frequency or volume of feedback request from one software application (e.g. smartphone app) is very high it might result in a negative reaction from them towards that software application (i.e. stop using the software application) and can also reduce their willingness to respond to feedback requests (see Table 9). This

is indeed an important issue that should encourage software developers to systemize the volume and frequency of feedback requests sent from a software application in a way that doesn't cause a negative reaction by users but empower their engagement and response rate to feedback requests.

TABLE 9 EFFECT OF HIGH FEEDBACK REQUESTS VOLUME ON USERS

Effect of High Feedback Requests Volume on Users	Percent of Users
It is fine with me, I like to give feedback often	3%
It is fine with me as long as I am not forced to give answers	13%
I tend to respond to some of them	14%
I tend to give less focused or less truthful feedback	10%
It leads me to give a negative feedback as the requests make me feel annoyed	7%
I tend to ignore all of them and I tend to consider it as a spam	53%
I tend to stop using the software sending me these requests	21%

D. Users' Clusters

Since there is a high level of variety among users' behaviours and preferences with regards to feedback acquisition in software applications, cluster analysis was used to further discover natural groupings in the data and to group similar participants together. The K-means clustering method was adopted [24]. K-means clustering is one of the widely used techniques to analyse a given set of data in order to produce meaningful clusters that can explain the natural grouping in data [25]. The initial clustering of participants served as an initial guide for the feedback acquisition process in which each group of similar users can be approached for feedback in a way that fits their preferences.

1. Main clusters

After conducting an intensive cluster analysis on the collected data, four main clusters that represented different groups of users were extracted. These initial clusters expressed the grouping criteria among users thus their behaviour with regard to feedback acquisition.

Some variables such as age, gender and level of education showed no significant influence on users' behaviour with regard to feedback acquisition. As shown in Table 10, the most influential clustering variables that drive users' behaviour with regard to feedback acquisition are:

- Users' acceptance of feedback requests (likeness of being asked for feedback).
- Methods used to gather users' feedback (e.g. offline by sending an email).
- Users' preferable type of feedback (e.g. explicitly asked for feedback).
- Users' acceptance of being reminded to respond to a feedback request.
- Social Variables:
 - a. Visibility and similarity of others feedback and its effect on users' willingness to give feedback.
 - b. Volume of already given feedback.

- c. Social recognition of feedback providers and its effect on users' willingness to give feedback.
- d. Feedback acquisition as a social activity and its effect on users' willingness to give feedback.

The previous drivers/variables for users' behaviour in regard to feedback acquisition are highly correlated and can collectively influence a user's assignment to a particular cluster. These variables have shown a correlation coefficient of 0.8483 which is considered to be a relatively high correlation. A logistic regression analysis was also conducted to predict the accuracy of the extracted clusters and users' assignment to a particular cluster (e.g. the accuracy degree in which a USER_x belongs to Cluster_x). The above users' behaviour clustering variables (see Table 10) were used as predictor and an overall prediction accuracy of 89.5% was achieved which is considered to be a good rate of accuracy.

2. Clusters Description

Cluster 1 (feedback antagonists) and Cluster 2 (passive and stingy people): these clusters represent a group of users who have negative views/perceptions towards all feedback acquisition methods. These user groups prefer not to be asked for feedback or to be reminded about it. Even social factors have no noticeable effect on their willingness to give feedback. The only thing that differentiates between both groups is the feedback acquisition method that they prefer if they were to be asked for feedback. In cluster 1, users prefer *online* methods such as feedback popup dialogue while using the software. However, in cluster 2 users' first preferred method is the *passive* one whereas their second preference is the online method. However, the two cluster groups have very similar negative views/perceptions about feedback acquisition. This encourages software developers to seek and tailor ways to fit these groups in order to change negative perceptions into a positive one and engage them more with the software.

Cluster 3 (privacy fanatic and generous people): this cluster represents the most positive users group among the 4 clusters. Users in this group do not mind to be asked *offline* for feedback and even sent a reasonable number of reminders to respond to feedback requests. However, they are very concerned about their privacy and therefore they put a great emphasis on the importance of asking them for feedback *explicitly* rather than in an implicit way (e.g. implicitly collecting information about their software usage). In addition, users' willingness in this group (to give feedback) is positively affected by the following social factors:

- **Volume of already given feedback:** users in this group indicated that a high number of feedbacks given on a service or a product empower their willingness to give feedback (positive correlation).
- **Visibility of other users' feedback:** They indicated that being able to see other people's feedback first and then having the option to accept/reject to give feedback can encourage them to give feedback.
- **Social recognition:** users in this group are more motivated to give feedback when they/their

feedbacks are being socially recognised by other users

Cluster4 (privacy tolerant and socially ostentatious people): this cluster represents the second positive users group among the 4 clusters. Users in this group do not like to be asked for feedback or reminded about it but their willingness to give feedback is highly affected by some social factors/variables such as similarity and visibility of others feedback. They also do not mind to be *implicitly* reached for feedback (e.g. implicitly collecting information about their software usage). However, their first preferable method (if they were to be asked for feedback) is using *hints and tips* to gather their feedback (e.g. by telling them that they can go to a feedback centre for this purpose and leave their feedback) whereas their second preference is the *online* method. Additionally, users' willingness in this group (to give feedback) is positively affected by the following factors:

- **Volume of already given feedback:** users in this group indicated that a low number of feedbacks given on a service or a product empower their willingness to give feedback (negative correlation).
- **Visibility and similarity of other users' feedback:** They indicated that being able to see other people's feedbacks first (that are similar to their feedback/opinion) and then having the option to accept/reject to give feedback can encourages them to give feedback.
- **Social recognition.**
- **Feedback acquisition as a social activity.**

The previous different types of users' clusters reflects the need to have an adaptive feedback collection mechanism which can highly empower and improve different aspects such as users' satisfaction, feedback quality, users' engagement with the software, software adaptation quality, etc.

VI. DISCUSSION

Our study of users' behaviour with regards to feedback acquisition provides a clearer view and a deeper understanding on how feedback acquisition should be designed. It answers questions that were highly ambiguous and unknown about users' reactions to feedback requests such as what motivates users to give feedback, why some users hold negative views about feedback.

Combining the findings of the first and second phases of our study, the results showed that users' perceptions and behaviours with regard to feedback acquisition significantly

vary and are affected by a number of factors. The variety among users' behaviours and the diversity of contextual information and design elements which affect that perception highlights the great need for an adaptive feedback acquisition process which accommodates such variety in autonomous or semi-autonomous way. It also raises awareness that feedback acquisition systems would need to be more context-aware. Amongst other things, feedback acquisition design should allow users to configure the way to receive feedback requests and express what information they would like to know before they give feedback and whether they want to see the effect of their feedback on the quality of service or the decision for the next release of the system.

The results show that there are a number of main factors and sub-factors that noticeably influence users' behaviour with regard to feedback acquisition in software applications. These main factors are; Feedback Acquisition Methods, Feedback Types, Users' Experience, Interface Design, Social Factors, Volume and Frequency of Feedback Requests. These behavioural factors should be highly considered by software developers at the early stages of feedback acquisition development process.

Having an adaptive feedback acquisition that can cater for such diversity is needed to make users looks more positively to feedback requests. This will have a positive side-effect on the feedback quality and truthfulness, users' involvement as decision makers, users' satisfaction and trust in the system. The good feedback, in quantity and quality, will increase developers knowledge about their users and software and software adaptation and success and help them decide how to evolve it or adjust it to enhance its role in meeting users expectations [3].

Fig.1, presents an initial application-independent conceptual framework for the design of an adaptive feedback acquisition. It summarizes our expert survey findings in [3] that are related to the motivation of an adaptive acquisition of users' feedback (right side of the figure). In [3], experts in software engineering agreed that availability of an adaptive feedback acquisition is a necessary enabler to decide ways of acquiring feedback and to empower the success of socially-adaptive software in particular and software systems in general. It also summarizes our findings on this paper and depicts the adaptation drivers from users' perspectives. In our future work, we will enrich this by looking at drivers from the perspective of information quality and software maintenance and evolution needs.

TABLE 10 INITIAL CLUSTERS OF USERS' BEHAVIOUR TO FEEDBACK ACQUISITION.

	N	Likenes to be asked	Method	Explicit/Implicit	Reminder	Visibility-Willingness increases	Social Activity-interest	Social recognition-willingness increases-impact	Feedback Volume	Feedback Similarity
Cluster 1	38	No	Online		No	No	No	No	No	No
Cluster 2	27	No	Passive+ Online		No	No	No	No	No	No
Cluster 3	21	Yes	Offline	Very Explicit	Yes	Yes_ If able to see others feedback first	No	Yes	Few-increase	50%
Cluster 4	14	No	Hint+ Online	Implicit is also OK	No	Yes_ If able to see others feedback first	Yes	Yes	Large-increase	Similar-increase

VII. THREATS TO VALIDITY

Although we have carefully followed the principles in conducting mixed methods approach, our study would still have three main threats to validity:

- While the methodology was effective in identifying and describing users' behaviour and perception with regards to feedback acquisition, it is possible that it did not identify all the important aspects and factors that can affect and influence their behaviour in this regard.
- One of the most common issues when designing a questionnaire is to know whether the questions were understood by all participants as intended and in a similar way to one another. This threat was somehow addressed as we conducted a pilot test on typical respondents who met our inclusion criteria then some questions were revised and modified to ensure that all participants share almost a common understanding of the questions.
- The sample size for the quantitative phase (100 participants) would be considered medium; a bigger group of participants might produce results that could be more generalized to other groups. Future research would further investigate our findings in this paper and perhaps study feedback acquisition for more specific groups of users and feedback.
- The majority of the participants were students and staff members from Bournemouth University which might introduce a population bias. However, to minimize bias and allow for more diversity among participants the rest of the participant (35) were recruited from different countries. In addition, being a student or staff member and holding a postgraduate or undergraduate degree doesn't really have noticeable impact on users' behaviour with regard to feedback acquisition as

suggested by the results of this study (see Section 6.4).

VIII. RELATED STUDIES

Hennig-Thurau et al [27] introduced several motives for users' engagement in an electronic word of mouth communication. Although our findings of users' motivations to provide feedback are slightly similar to [27], our starting point was different in that the main focus was on users' motivations for giving feedback where users are targeted with feedback requests from software applications to assess the quality of the software behaviour. In other words, our study focuses on users' reaction, perceptions and motivations to give explicit feedback in response to feedback requests to evaluate the software application's quality and validity in meeting user requirements.

Additionally, Pagano and Bruegge [10] conducted an empirical case study on five professional software development companies to explore the current practice of users' involvement via their feedback. Their study mainly focused on the stages after feedback has been collected (e.g. structure, analyse, and track users' feedback) and no much attention was paid to the earlier stage where feedback collection activity takes place. Additionally, our study was built on the fact that users' behaviour with regards to feedback requests is an important factor to be studied to allow software developers to understand and know their audiences. Hence tailoring the right acquisition method to each different type of users in a systematic manner will have positive implications on the quality of the software, users' feedback and satisfaction.

Furthermore, Pagano and Maalej [9] conducted an exploratory study that analysed over one million reviews from the Apple AppStore. One of their study's objectives was to investigate the impact of users' already given feedback on the

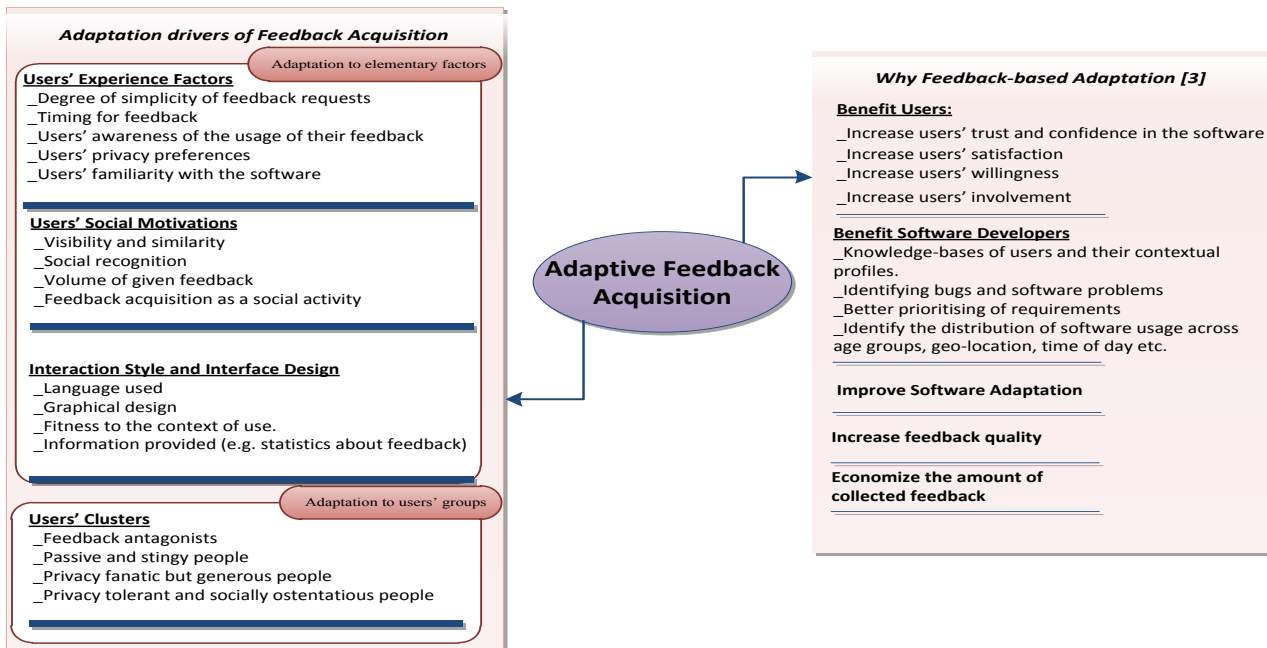


Fig.1. Conceptual framework for an adaptive acquisition of users' feedback.

user community. Their findings suggested that visibility of already given feedback has a noticeable negative/positive impact on the app ratings as well as the community (e.g. users' experience). We argue that the visibility of others feedback has a larger range of effect and can also negatively/positively affect users' willingness to participate and respond to feedbacks requests (see users' behaviour in Cluster2 and Cluster4).

In regard to feedback acquisition, there are several available tools for gathering users' feedback in software systems in different forms (e.g. text, images and videos) and many of them also include context capturing functionality. Common examples are; UserVoice¹, Get-Satisfaction², IdeaStorm³, VoiceYourView⁴ and iRequire [28]. However, all of these tools are limited in terms of adaptivity to various users' behaviour. This can highly harm the quality of collected feedback and users' experience thus software's success. In addition, a systematic practice to gather users feedback is still missing in these tools (e.g. when to proactively ask users' for feedback?). This indeed highlights the need for a systematic and adaptive way to gather users' feedback.

IX. CONCLUSION

In this paper, we have conducted and reported on an empirical mixed method study to explore and investigate users' behaviour with regard to feedback acquisition in software applications. Users' were studied first qualitatively and then quantitatively to enhance our results and allow for more generalization. We found that users' behaviour with regard to feedback acquisition highly varies and is influenced by a number of behavioural factors. Our results suggest that systematic approaches and mechanisms to conduct an adaptive feedback acquisition are highly needed. These approaches and mechanisms should fit and adapt to each different user type and should highly consider the factors that influence users' behaviour during the feedback acquisition process. Availability of such systematic approaches for an adaptive feedback acquisition can greatly improve the quality of users' feedback, users' satisfaction and the quality of socially-adaptive software.

ACKNOWLEDGMENT

The research was supported by an FP7 Marie Curie CIG grant (the SOCIAD Project) and by Bournemouth University through the Fusion Investment Fund (the BBB and VolaComp and BUUU projects) and the Graduate School PGR Development Fund. We also thank Hamid Bouchachia and Emilio Balaguer for insights on conducting clusters analysis.

REFERENCES

- [1] R. Ali, C. Solis, I. Omoronyia, M. Salehie, B. Nuseibeh, 2012, "Social adaptation: when software gives users a voice," In ENASE'12.
- [2] B. Cheng, et al. 2009, "Software engineering for self-adaptive systems: A research roadmap," Springer Berlin Heidelberg.
- [3] M. Almaliki, F. Faniyi, R. Bahsoon, K. Phalp, R. Ali, 2014, "Requirements-driven Social Adaptation: Expert Survey," In REFSQ'14
- [4] N. Esfahani, S. Malek, 2010, "Social computing networks: a new paradigm for engineering self-adaptive pervasive software systems," In ICSE'10.
- [5] S. Fickas and M.S. Feather, "Requirements monitoring in dynamic environments," In RE'95.
- [6] D. Garlan, S.W. Cheng, A.C. Huang, B. Schmerl, P. Steenkiste, "Rainbow: Architecture-based self-adaptation with reusable infrastructure," Computer, 2004.
- [7] P. Oreizy, et al, "An architecture-based approach to self-adaptive software," Intelligent Systems and Their Applications, IEEE 14.3: 54-62.
- [8] P. Sawyer, N. Bencomo, J. Whittle, E. Letier, A. Finkelstein, 2010, "Requirements-aware systems: A research agenda for self-adaptive systems," In RE'10, pages 95-103.
- [9] D. Pagano, W. Maalej, 2013, "User feedback in the appstore: An empirical study," In RE'13.
- [10] D. Pagano, B. Bruegge, 2013, "User involvement in software evolution practice: A case study," In ICSE'13.
- [11] T. J. Gordon. 1994, "The delphi method. Futures research methodology," 1-33.
- [12] R.M. Cooke, K.N. Probst, 2006, "Highlights of the expert judgement policy symposium and technical workshop," Resources for the Future Washington, DC.
- [13] S. Franklin, C. Walker, S. Canada, 2003, "Survey methods and practices," Ottawa:Statistics Canada.
- [14] W.C. Leung, 2001, "How to design a questionnaire," Student BMJ, 9, 187-189.
- [15] R. Adolphs, 2002, "Recognizing emotion from facial expressions: Psychological and neurological mechanisms," Behavioral and cognitive neuroscience reviews 1.1, 21-62.
- [16] M. Stevens, 2010, "Chapter 7: Selected Qualitative Methods: Why Use Qualitative Methods," Painconsortium.nih.gov.
- [17] P. Gill, K. Stewart, E. Treasure and B. Chadwick, 2008, "Methods of data collection in qualitative research: interviews and focus groups," British dental journal, 204 (6), 291-295.
- [18] Olivia, 2012, "Difference between observation and interviewing as methods of data collection," Difference Between.
- [19] J. Creswell, 2013, "Qualitative Inquiry And Research Design: Choosing Among Five Approaches," 3rd. Sage Publications, Inc.
- [20] S. Baker and R. Edwards, 2012, "How many qualitative interviews is enough? Expert voices and early career reflections on sampling and cases in qualitative research," Middlesex University, University of Southampton.
- [21] M. Miles, and A. Huberman, 1994, "Qualitative data analysis: An expanded sourcebook," 2nd. Sage.
- [22] A. Tashakkori and C. Teddlie, 1998, "Mixed methodology: Combining qualitative and quantitative approaches," Vol. 46. SAGE Publications, Incorporated.
- [23] A. Williams, 2003, "How to... Write and analyse a questionnaire. Journal of Orthodontics," 30 (3), 245-252.
- [24] K. Alsabti, S. Ranka and V. Singh, 1998, "An efficient k-means clustering algorithm," In IBDPS'98
- [25] R. Zwitch, 2013, "Clustering Search Keywords Using K-Means Clustering," R-bloggers.
- [26] M. Hall, E. Frank, G. Holmes, B. Pfahringer, P. Reutemann and I. Witten, 2009, "The WEKA data mining software: an update," ACM SIGKDD Explorations Newsletter, 11 (1), 10-18.
- [27] T. Hennig-Thurau, K. Gwinner, G. Walsh and D. Gremler, 2004 "Electronic word-of-mouth via consumer-opinion platforms: what motivates consumers to articulate themselves on the internet?," Journal of interactive marketing, 18 (1), 38-52.
- [28] N. Seyff, F. Graf and N. Maiden, 2010, "Using mobile re tools to give end-users their own voice," RE'10.

1 <https://www.uservoice.com>

2 <https://getsatisfaction.com>

3 www.ideastorm.com

4 <http://www.voiceyourview.com>.