

A Framework to Support Delphi Methods

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Abstract

The Delphi method is a structured group communication technique which aims to achieve a convergence of opinion on a specific real-world issue. It is an iterative questionnaire exercise to an anonymous group of experts. However, there aren't many online frameworks that explore the Delphi method. The main objective of this work was the development of a new framework to support the Delphi method, aiming at the main characteristics of the method. Some frameworks were analyzed in order to understand the specific aspects of the Delphi frameworks. The first version proposed of the new framework was evaluated by eighteen users. After the feedback of the solution proposed, it was made some improvements.

Keywords: Delphi method, framework, data collection, experts consensus

1. Introduction

The Delphi technique was developed by Dalkey and Helmer at the Rand Corporation in the 1950s [1]. It is a method of gathering the collective opinion of a group of experts on a particular topic. The technique consists of a series of questionnaires sent to a group of experts. The idea of the Delphi method is to overcome the disadvantages of traditional surveys. The experts communicate their opinions and knowledge anonymously about a particular topic without feeling embarrassed about changing their ideas [3]. The main objective of this work was the design and development of a framework to support the Delphi study focusing especially in the main features of the Delphi method. In the structure of the questionnaires was used a Q-Sort matrix, component of Q Methodology. Q Methodology is a research method to study of participants viewpoints.

Having analyzed relevant works to the development of the new Delphi framework, it was designed some prototypes in order to assess the requirements for an appropriate solution.

In the development phase of the solution was used evolutionary prototyping. In evolutionary prototyping, the system evolves from a very limited initial version to its final version [2]. Accordingly it is highly recommended the evaluation with users to obtain feedback of the solution. After the evaluation, it was made some improvements which resulted in the final version of the new framework.

2. Background

The Delphi method originated in studies that the RAND Corporation conducted in the 1950s. The objective was to develop a technique to obtain the most reliable consensus of a group of experts [4]. Exist many definitions of the term Delphi, the most accepted for the Delphi, which is a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem [7].

2.1. Characteristics of the Delphi method

The Delphi technique is a method for consensus building and decision-making processes by using a series of questionnaires to collect data from a panel of experts [5]. The most important characteristics of the Delphi technique are listed below:

- **Anonymity** - Anonymity of individual responses is one of the key features of the Delphi technique. The experts do not know the responses of the other specialists. The experts will not know the responses of other specialists.
- **Feedback** - Feedback is the optional comments where the experts can suggest some additional information for research or justify their choices in the survey.
- **Iterations** - Iterations are the number of rounds. The Delphi method requires a minimum of two rounds. In the original Delphi it is recommended to use four rounds. However

it has been greatly altered by the changes introduced in the method, most of the Delphi studies end with two or three rounds.

- **Statistical analysis** - The Delphi was originally developed as a means for gaining consensus. Statistical summaries used in Delphi studies are statistical measures in order to summarize the information concerning the collective judgments of the experts.

2.2. The Delphi Process

The Delphi process is systematic and its goal is to gather information through of the survey on a specific topic. The Delphi process and the structure of the group communication process is important to evaluate the experts consensus [9]. There are different possibilities for Delphi process. The most important steps points in [3].

- **Researcher** -Who wants to do the study. Someone with knowledge about Delphi method, research and data collection.
- **Experts** - An expert is someone with knowledge or experience in the study topic.
- **Study topic definition** - It must be clear, the experts need to recognize what they are judging. The researcher is responsible to ensure a clear definition of the study topic.
- **Round Delphi**- Most of the Delphi studies end with three rounds, but the number of rounds is determined by researcher. The researcher creates as many rounds as needed to obtain the experts consensus.
- **Statistical analysis**- Statistical analysis from the rounds calculate the experts consensus. The consensus is normally done analyzing statistically the quantitative data (e.g. means, median or kendall's w coefficient of concordance).

Before starting the implementation of the new framework the following frameworks was studied and analyzed to gain knowledge about the specific aspects from Delphi frameworks.

2.3. Likert Scale in Delphi framework

Some Delphi studies, describe the result obtained in Delphi framework that use the Likert scale in the questionnaire design. The Likert scale is used in the structure of the questionnaire to measure experts opinions. In Likert scale, when responding to a Likert questionnaire item, the experts specify their level of agreement (level 5, 7 or 11) or disagreement (level 1) on a symmetric agree-disagree scale for a series of statements. A Likert item is a

statement that the expert is asked to evaluate by giving it a quantitative value, with a level of agreement/disagreement being the dimension most used. However, the most controversial issues in Delphi application are related with the questionnaire design using the Likert scale. Experts can always agree to the statements presented and the validity may be difficult to demonstrate.

2.4. Delphi Decision Aid Framework

Delphi Decision Aid is a free tool programmed in PHP that supports Delphi method. This tool allows the collection of data in anonymous surveys to obtain expert judgment. There are different types of questions pre-configured by the researcher:

- **open-ended questions** - Open-ended questions are questions that allow experts to give a free-form answer.
- **Scale question** - The experts assign a value numeric to the question. It is possible select an only scale for the question.
- **Ranking question** - The experts compare items to each other by placing them in order of their preference.

However, some functionalities present some flaws. The questionnaire can have many types of questions (open-ended questions, scale question for ranking question). However, different type of questions in a single questionnaire can affect the survey result. There are many steps to create a questionnaire and the framework only allows write one question at a time. When click in button to add question the users go directly to next page, which can lead to a poor user experience and usability. To add a new question the users should to return the previous page. In consequence, add many questions in questionnaire is very time consuming. Overall, despite the framework only allows write one question at a time, it's quite useful to understand the all steps to create a Delphi studies and the main features of the method.

2.5. e-Delphi Framework

Professor Santos of the University of Minho developed the Delphi framework to collecting opinions from a panel of experts. It was developed the e-Delphi framework to support data collection based on the Delphi method and technique Q-Sort. It was considered important to analyze and study the e-Delphi framework to understand the specific aspects in this framework.

In e-Delphi framework the first step consists of grouping the questions into three groups. After authentication in the framework, the expert should separate the question in three groups, one with the

”very important” questions, the other with the ” little importance questions and finally one with the ”of regular importance” question.

After the distribution of the questions in the three groups in the next step the questions should be distributed by the Q-Sort matrix. This framework presents two steps. For many questions these steps become a slow and exhausting process for the experts.

In general, the tool has a great manner to execute the method and present the results.

3. PROBLEM AND SOLUTION DESIGN

In general, the problem is design and develop the new framework to support the Delphi method with a simple and consistent user interface taking in consideration the main objectives.

3.1. Use Case

In order to develop a new framework is considered a set of use cases, associated to a set of actors. The use case presented below (Fig.1) displays requirements the final version of the new Delphi framework.

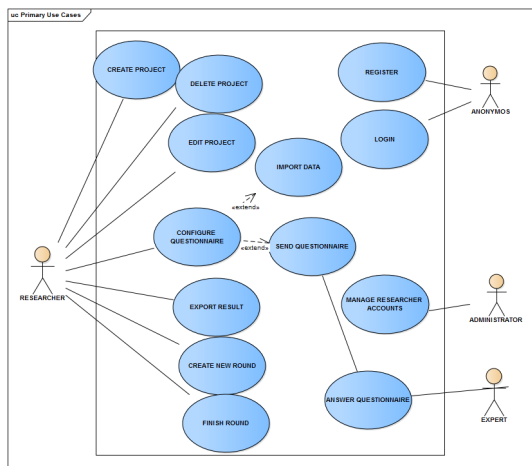


Figure 1: Use Case

The user authenticated have different privileges. An administrator manages the researcher accounts. A researcher is the user who interacts with the main functionalities of the framework. The researcher can create a project by giving it a name and choosing if the Delphi study is anonymous or not anonymous. The choice of anonymity only allows the researcher to know the responses of each experts. Anonymity of individual responses among experts is always guaranteed. After a project is created the researcher can delete the project, edit some of the projects fields (its name or its type) or open a project. After opening a project, the researcher views the methods steps that are required to import the questionnaire and send to experts. All experts

receive an email invitation to participate in the Delphi study. The experts responses the questionnaire and sent their response. After that, the researcher can export responses. The researcher can finish the current round or start new round to obtain the experts consensus.

3.2. Structure of the Questionnaire

In the design phase it was decided to develop a system using the Q-methodology in the questionnaire structure. The Q-methodology was developed by William Stephenson. This methodology has been used in research settings to examine how people think about a topic. The Q-Sort technique, components of the Q-methodology, is based on the Q-Sort matrix (Fig.2).

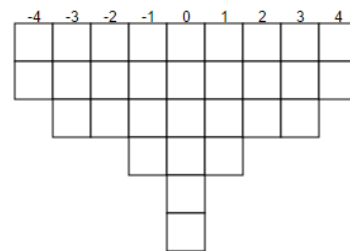


Figure 2: Q-sort Matrix

The score of Q-Sort matrix is continuous ranging from most disagree to most agree, between a distribution that usually takes the form of a quasi-normal distribution. In Q methodological, the people are presented with a sample of statements about some topic. Respondents (experts) are asked to rank-order the statements from their individual point of view, according to some preference, judgment or feeling about them, mostly using a quasi-normal distribution. These individual responses (or viewpoints) are then subject to analysis and interpretation. The experts are instructed to rank the statements according to some rule, typically the persons point of view regarding the issue. In general the Q-Sort technique in the questionnaire structure was considered the most adequate solution than the use of Likert scale or other type of scale.

3.3. Technology

The technologies used are the base of a MEAN application which consists in using MongoDB, Express and Node JS for the back-end and AngularJS for the front-end. MEAN application allows the web applications development using only JavaScript language.

- MongoDB is a NoSQL database uses JSON document, high availability, scalability and easily querying through a JavaScript framework.

MongoDB works on concept of collection and document.

- Express is a flexible Node.js web application framework that provides a set of features for web.
- is a very extensible framework, extends HTML pages through checks and extensions to the HTML language.
- NodeJS is a runtime environment for executing JavaScript code server-side.

4. SOLUTION IMPLEMENTATION and EVALUATION

The proposed solution is based on the requirements to create a Delphi framework with a web-based human interface. This section describes the solution implementation.

4.1. Main Page

The main page (figure 3) of the Delphi framework is the first page to access by the users. It provides some information where the users create a new account and login into the framework. From the main page the user has direct access to the login page and signUp page.

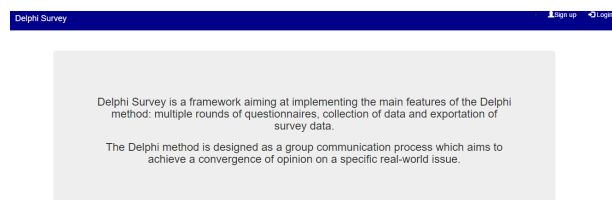


Figure 3: Main Page

The sign up page the users can create an account by providing: username, email and password. In the login page the user provides username and password to access the framework. However, if in the database not existing an account with the username and password provides by user in login operation, the operation is canceled and an error message appears.

4.2. Delphi Project Page

If login operation is successfully the users are redirect to respective Delphi projects page (figure 4). In Delphi projects page contains some information about each project like name, type, number of the current round, round status and round creation date.

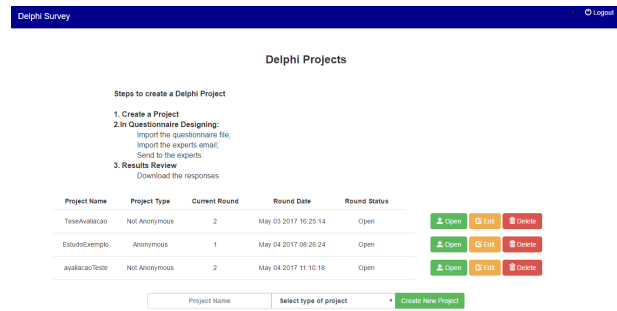


Figure 4: Project Delphi Page

In the "Create New Project" button allows users to create new project. The project created presents in project list contains three different types of functions. The open function (Open button) opens the project selected and the user go directly to the questionnaire designing page (figure 5), if the questionnaire is not configured and sent to experts. In the case of questionnaire was configured and sent to experts the user is redirect to Overview page. The edit function (Edit button) allows changing the project name and type. Finally, the Delete button deletes the project selected and the respective data in the database.

4.3. Questionnaire Designing Page

After creating a new project, the user need to set up the questionnaire and send it to the experts. In the questionnaire designing page the user views the methods steps that are required to import the questionnaire and send to experts.

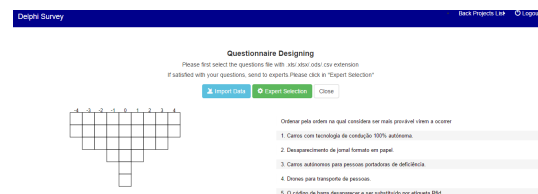


Figure 5: Questionnaire Designing Page

The page provides some information about to import file of questionnaire and select the experts. The user should choose the file with the questionnaire (the file should be in csv / xls / xlsx / ods format). After importing the file a Q-Sort matrix and the list of issues are drawn, the list of questions is save in database. To send questionnaire to the experts the user should be click in "Selection Experts" Button", then import the list of experts email and send.

4.4. Page Result

In order to view the result of a round, in the overview page, the user should select the "Show" result button of the desired round. In result page

(figure 6) the users can see sum chart for each question, the percentage chart of the responses and the some information about number of questions sent, number of experts and the number of responses.

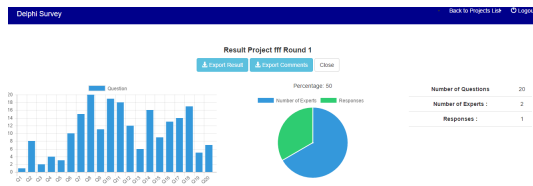


Figure 6: Result Page

To export the responses of a round, the users should press the "Export Data" button to export the responses of the experts, or press the "Export Comments" button to export the optional comments of the experts.

4.5. Expert Page

The experts receive an email to invite to participate in the Delphi study. To participate, the expert should access the hyperlink to fill in the questionnaire on the Delphi Survey website (figure 7).

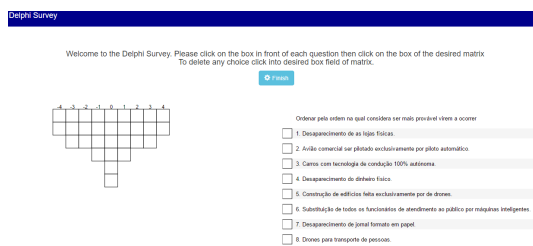


Figure 7: Expert Page

After completing the Q-Sort matrix, the expert sends his responses. Each experts can suggest (in the comment field) new questions which considers important to survey or justify their choice.

4.6. Evaluation

It is intended with the new framework provides its users good user experience and good usability. Usability testing allows gather feedback on how users use and feel about new product

Process

According usability parameters point in [8] , a set of typical tasks of the new Delphi framework was elaborated for the evaluation with users. The main purpose of this evaluation focuses on identifying some problems associated with the user interface and evaluate the usability and the user experience of the first version of the framework.

Before starting the evaluation each user received the following documents: User Manual - It contains a brief description of the framework and presents a tutorial how every function works.

User Evaluation Guide - It document contains the configuration necessary for the evaluation, the tasks to be performed in the evaluation and the hyperlink of the user evaluation survey (made based on the Google form).

Zip file containing a folder with .xlsx files to be used for specific tasks.

Participants and Tasks

Eighteen users collaborated in the evaluation, each user execute the same tasks. The estimated time for the evaluation was between 15 and 25 minutes.

After receiving the files, each user performed the tasks presented in the User Evaluation Guide using the first version of the framework. The estimated time for the evaluation was between 15 and 25 minutes. The proposed tasks consisted in using all its available functions of the new framework in order to receive the respective feedback.

The evaluations were made in person, while another evaluations were made online using the Skype application with the screen sharing. The evaluation allowed note the time taken to complete the tasks, the user interaction and identify eventual problems or mistake.

User Evaluation

After finished all the tasks in the framework, all users answered the survey (in Google form) to measure the level of usability, user experience and identify weaknesses or areas to be improved in the framework. The survey was divided in three parts (usability, user experience and personal opinion).

Usability refers to the quality of a user's experience when interacting with systems. Usability is about effectiveness, efficiency and the overall satisfaction of the user [8].

The user experience refers to a person's attitudes about using a particular system, presentation, functionality, persons perceptions of system aspects such as utility, ease of use and efficiency [6].

Result

In general the users considered most of the available functions very easy to use with the exceptions of the Finish round function was classified as easy. The average time that users took to execute all the tasks was 19.7 minutes. The most users has performed the evaluation inside the respective duration.

In general, the satisfaction for the whole experience was almost very satisfactory between users. The figure 8 presents that users rank the available functions as useful regarding the Resend email to experts do not participate, Export Expert Comment, Percentage response graph and the Percentage response graph.

Question	2.1	2.2	2.3	2.4	3.1	4.1
Mean					4.3	4.4
Median	d	c	c	d	4	4

Figure 8: Responses to usability issues 2, 3 and 4: mean and median

Considering the figure 9, overall it can be observed that the user experience was good based on the results average.

Question	5	6	7	8
Mean	4.4	3.8	4.1	4.3
Median	5	4	4	4

Figure 9: Responses to user experience issues from 5 to 8: mean and median

All suggestions provided by the users were analysed. Some of them can be considered for future work as they can improve the framework.

5. Conclusions

The Delphi method consists of an iterative process of inquiries to a group of specialists which aims to achieve a convergence of opinion on a specific real-world issue.

However there are not many web tools that exploit the method Delphi.

In order to develop a solution to the presented problem, some Delphi frameworks have been studied and analysed in order to obtain a solid understanding of the features and requirements of the Delphi method and understand specific aspects of other framework. Some aspects considered relevant were reused from other framework, such as the use of the Q-Sort technique in the structure of the questionnaire. A new Delphi framework was developed using evolutionary prototyping methodology, the features of the proposed solution were added improved gradually to the final version.

The tool was evaluated by a group of users. According to the result obtained and some suggested improvements, corrections and improvements were made that resulted in the final version

5.1. Future Work

Some suggestions received were not implemented due to time constraints For exemple:

Implement an algorithm to sort the results of a round;

Create a page with a list of all panel members and signal with a different color an member who has replied;

Add a help section on the Expert Panel page with the Q-Sort step description; Allow the export of results in other formats besides CSV.

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