Knowledge Engineering Methodology with Examples

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INTRODUCTION

This article will present a brief look at knowledge engineering (KE); a KE method in common use called Delphi; some controversies as to the Delphi and face-to-face methods and a Delphi paradigm that uses small groups, face-to-face. The Delphi has been used often in knowledge engineering efforts. The use of small groups to elicit data has a similar history. However, the use of small groups in a non-anonymous Delphi setting seemed to the author to have some benefits. The main focus here will be on the development and use of this modified Delphi, called the Small Group Delphi Paradigm (SGDP). The SGDP uses subject matter experts (SME's), coupled with Fleishmann's work on underlying abilities, in a highly structured group environment. This has produced several selection tests, training criterion and products, task analyses and, highly specific managerial/employee core competencies. In sum: The SGDP has been used in many environments, which demonstrates a robust flexibility and generalizability of the paradigm. The article will detail the structure and procedures for using this KE model for use across many venues.

BACKGROUND

Knowledge Engineering

KE was defined in 1983 by Edward Feigenbaum and Pamela McCorduck as follows: "KE is an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise." Some of the possible uses and functions of KE are: articulation and assessment of an issue/problem; development of a knowledge-based system structure for dealing with issues/problems; obtaining and structuring relevant information and knowledge; developing tests for validation of the obtained information/knowledge...and more. Since the mid-1980's, KF has grown in use and importance concomitant with the advances in computer memory, capabilities and useage. Knowledge engineering is also linked to cognitive science and socio-cognitive engineering where the knowledge is produced by socio-cognitive aggregates (mainly humans); this was one rationale for the SGDP. Additionally, KE is often an iterative process with many challenges. Thus, since KE can be seen as somewhat more art than engineering, there are no neat boundary lines as to what constitutes KE, with resultant controversies.

Of some import are these facts: KE has become closely allied with the field of artificial intelligence (AI); there is a division within the arena of KE between the transfer view of KE and the modeling view. It is beyond the scope of this article to explicate this division. For a more complete overview and discussion on KE, differing views and uses the reader is referred to Studer, Benjamins and Fensel (1998). Finally, there is a somewhat new emphasis on the KE/philosophical field of ontology as to building a model of a knowledge domain, defining the terms inside that domain and the relationships among them.

The Delphi Method (Process; Technique)

The Delphi method (sometimes referred to as a process or technique...all terms are somewhat accurate) is a structured KE technique, originally developed as a systematic, interactive forecasting method which relies on a panel of anonymous (to each other) experts. It has since been changed and expanded to become a tool for KE using experts in a variety of venues. The experts answer questionnaires in two or more rounds.

After each round, a facilitator provides an anonymous summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Thus, experts are encouraged to revise their earlier answers in light of the replies of other members of their panel. It is believed that during this process the range of the answers will decrease and the group will converge towards the "correct" answer. Finally, the process is stopped after a pre-defined stop criterion (e.g. number of rounds, achievement of consensus, stability of results) and the mean or median scores of the final rounds determine the results.

Characteristics

The following key characteristics of the Delphi method help the participants focus on the issues at hand and, what separates Delphi from other methodologies:

1.   Anonymity of the participants

Usually all participants remain anonymous. Their identity is not revealed, even after the completion of the final report. This prevents the authority, personality, or reputation of some participants from dominating others in the process. Arguably, it also frees participants (to some extent) from their personal biases, supposedly minimizes the "bandwagon effect" or "halo effect," allows free expression of opinions, encourages open critique, and facilitates admission of errors when revising earlier judgments.

2.   Structuring of information flow

The initial contributions from the experts are collected in the form of answers to questionnaires and their comments to these answers. The panel director/facilitator controls the interactions among the participants by processing the information and filtering out irrelevant content. This avoids the possible negative effects of face-to-face group discussions and thereby, solves any problems resulting from group dynamics.

3.   Regular feedback

Participants comment on their own responses, the responses of others and on the progress of the group/panel as a whole. At any moment they can revise their earlier statements. Again, the claim is made that, while in face-to-face group meetings, participants tend to stick to previously stated opinions and often conform too much to the group leader. What will now be termed the "traditional" Delphi method handles this objection.

4.   Role of the facilitator

The person coordinating the Delphi method can be known as a facilitator or leader, and facilitates the responses of their panel of experts, who are selected for a reason, usually that they hold knowledge on an opinion or view. The facilitator sends out questionnaires, surveys etc. and, if the panel of experts accept, they follow instructions and present their views. Responses are collected and analyzed, then common and conflicting viewpoints are identified. If consensus is not reached, the iterative process continues to gradually work towards synthesis and building consensus.

The Rand Corporation was a leader in developing and using the Delphi Process/Method/Technique. A seminal paper on the Delphi process was written by a then-Rand employee (Brown, 1968) and may be available from Rand or from ASTME (American Society of Tool and Manufacturing Engineers; now known as Society of Manufacturing Engineers; Michigan).

What has been presented above is the standard description and rationale for the Delphi process. In the author's opinion, the objections to face-to-face interaction not only can be overcome but the use of group dynamics coupled with traditional Delphi processes can add robustness and a completeness, as it were, to results obtained from this coupling. In short; there are alternatives, other pathways and modifications as will be seen.

The Underlying Abilities Concept of Fleischmann

Humans perform multiple tasks on a daily basis. The factors that have an effect on task performance have been studied for many years. In their book, *Taxonomies of Human Performance*, Fleischmann and Quaintance (1984, revised 2000) state that "specific tasks are said to require certain ability profiles if performance is to be maximized. Abilities provide a natural basis for describing and classifying tasks in terms of human performance requirements." Fleishmann and Quaintance

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