The HERO e-Delphi system: Overview and implementation

October 2001

Background

The Delphi method describes an approach to group collaboration designed to foster the exploration and distillation of expert opinion. The method does not describe a specific series of tasks; rather, it is a flexible implementation of a set of guidelines for structuring group communication (Helmer 1983). The problems to which the method is applied are generally complex and lack an easily defined or readily agreed upon solution. The method allows individuals to express and defend their beliefs about possible solutions with the aim of generating a body of expert opinion that bounds the breadth and depth of the problem space.

The Delphi method originated at the RAND Corporation after World War II as a tool for forecasting aspects of future warfare (Cornish 1977). The impetus for its development was the problem of defining clear statements of belief regarding problems for which there is not an easily defined answer; in such instances, expert judgment must be an important element of decision making. Overcoming biases in individual judgment requires the input of a group of experts. While face-to-face communication can be an effective means of collaboration, group meetings nonetheless suffer from several shortcomings (particularly when there are more experts than can effectively communicate in a face-to-face setting). The free expression of ideas can be hindered by personality conflicts, status relations, and unwillingness to express certain beliefs publicly. Moreover, articulating and sharing a set of well-defined solutions – appropriating individual beliefs as group beliefs – demands that opinions are well organized and quantified. This requirement in turn demands a degree of structure to the group's communication, structure to which it can be difficult to adhere during face-to-face group discussions. Designed to counteract many of these shortcomings, Delphi exercises are a method for collecting group judgment that allow asynchronous and spatially dispersed interaction; they emphasize individual contributions and individual choices, the body of which come to represent group choices through an iterative process (Adler and Ziglio 1996).

While commonly conducted as pen-and-paper exercises through the mail, increasing access to electronic networks (and the advantages in communication speed, data processing ability, and dynamism of content such networks offer) makes electronic versions of Delphi procedures attractive collaboration tools. The Delphi method is only one approach to group communication, and only one of the many ways in which HERO collaborators interact, but it can offer unique perspectives on complex problems.

Principles of Delphi

Delphi activities are fundamentally exploratory tools, where individuals plumb their knowledge, share it with others, and use what is shared with them to refine their own

thinking. Delphi activities are not intended to generate consensus, although it is possible for consensus to emerge. Delphi activities are also not intended to quantify beliefs, although quantification can help focus participation. The goal of Delphi activities is simply to reveal (not create) patterns of thought, areas of consensus or disagreement, or questions to pursue.

There are numerous shortcomings of the Delphi method, not least of which is that results are only as good as the opinion that produced them. Delphi results are also highly sensitive to the quality of the questionnaires. In addition, the method does not allow interactions among forecasted elements to be easily addressed. Basu and Shroeder (1977) test the performance of the method empirically, however, and report that Delphi exercises are still capable of producing more accurate forecasts than other survey devices.

The Delphi method can be summarized simply as a communication tool that adheres to the following four principles (Linstone and Turoff 1975):

Anonymity

When participants' identities are not associated with their contributions, they may be more willing to share beliefs that are unpopular, risky, or do not match others' preconceived notions of what to expect from them. Moreover, status will not affect participants' willingness to contribute ideas or the support others give to them. Participants can also change their votes more freely if their name is not associated with the votes (Delbecq et al. 1975). In short, anonymity ensures that panelists' personalities do not influence group behavior. While respondents' identities may often be known to the Delphi moderator, materials presented to the panel should avoid revealing the identity of the contributor to the extent possible.

In contrast to unstructured electronic communication tools (such as chat rooms or unmoderated message boards), contributors to a Delphi exercise are nearly always selected by a moderator or researcher. Because Delphi activities are designed to elicit the beliefs of experts, and the constitution of a panel has a significant impact on the products that panel generates. Participants need to feel that they are communicating with a peer group for them to become honestly engaged in the discussion. In the case of HERO's first e-Delphi exercises, participants will be HERO team members and will likely know (or know of) each other. The ethos of each participant is created by his or her affiliation with the project; while participants will likely know who else is participating, they should not be able to identify individual responses with another participant's identity.

There are disadvantages to full anonymity, including flaming and spurious contributions. In some future e-Delphi activities, participants may be allowed to choose to use their real names (if a group of collaborators knows each other and knows their ability to work together already, their progress can be expedited by full disclosure of identities) or pen names or profiles, which can be used to share information about a participant (expertise, location) without revealing a full identity. Pen names are useful when participants want to be able to see what ideas came from a single person, or want to understand whether

themes common to many contributions came from different participants or whether they are all the contributions of a single participant. Profiles may be especially useful when e-Delphi panels include personnel not directly affiliated with HERO.

Asynchronicity

Turoff and Hiltz argue that the most important element of a Delphi procedure is the ability of participants to participant when and how they want to. In contrast to face-to-face discussions, in which all participants must discuss the same topic at the same time, asynchronous communication allows participants to reflect on their contributions at their own pace. Depending on their expertise or comfort, they may participate fully throughout the process or jump in only when discussion moves toward an area with which they are familiar.

Turoff and Hiltz describe ten steps to group decision making:

1. Recognizing the problem
2. Defining the problem
3. Changing the representation of the problem
4. Developing the goals associated with solving the problem
5. Determining the strategy for generating possible solutions
6. Choosing a strategy
7. Generating the evaluation criteria to be applied to solutions
8. Evaluating the solution criteria
9. Generating the solutions
10. Evaluating the solutions

While these steps outline the process of collaboration, they can also describe the process individual contributors use to frame their own understanding of and solutions to a problem. An electronic Delphi system should allow users to explore each of these steps individually, and at their own pace (within the bounds set by a moderator; see below)

Most pen-and-paper Delphi exercises, and HERO's initial e-Delphi exercise, use a series of rounds to organize discussion around the ten elements above. The round structure is an effective means of ensuring that communication progresses steadily toward a goal, but it can also force participants to move forward when they are not ready, or to accept interim solutions that are not ideal. Future exercises may exploit the benefits of asynchronous interaction by allowing more fluid explorations of a topic. Continuous feedback ought to allow participants to view the set of contributions in different ways (e.g., by date or by theme), tailoring their participation to their skills and expertise. Participants should be able to reconstruct and reconfigure the contributions or voting results from one or more rounds to aid their own decisions and contributions for each step. While future exercises may not use formal rounds, focusing the panel's work will require a set of activities (e.g., votes) that each member of the group will perform.

Controlled feedback

Delphi is an iterative process; the results of one activity or question are used to inform the creation of the next. The control of feedback applies to both participants and moderator. The Delphi activities are structured so that panelists participate in certain controlled ways. For example, they might be asked to provide verbal comments of a certain length, or asked to rate their approval of a concept using a Likert scale. When the input of all participants takes a common form, it is relatively easy to aggregate. The moderator must also provide participants with feedback about the outcomes of previous rounds or activities. The moderator controls the style and amount of feedback and attempts to return information to the panel in an unbiased manner. Controlling feedback also means that the moderator may withhold the results of voting until enough votes have been received, or edit responses for length or clarity (Murry and Hammons 1995).

Statistical response

A common goal of Delphi activities is to generate quantitative expressions of individual and group belief from qualitative expressions of thought. Thus, panelists are provided with tools to quantify their beliefs and to rate their confidence in a belief or their satisfaction with an outcome. During feedback, the panel viewpoint as expressed in these quantitative measures is summarized statistically, using mean and deviation (Khorramshahgol et al. 1988).

Role of the moderator

Nearly all Delphi activities require, to a greater or lesser extent, a human facilitator to manage the feedback, initiate activities, and focus the panel. In traditional pen-and-paper activities, the moderator plays a central role; all responses pass through the moderators hands before being presented to the group. The moderator may edit responses, form new questions based on those responses, summarize contributions, and decide on the order and style of each round. Electronic Delphi activities can reduce the role of the moderator, but generally do not eliminate it. Panelists' contributions can be posted directly for the group to see (as in a message board), and panelists may be given authority to call for a vote on certain topics if they feel that common themes are beginning to coalesce. Nonetheless, depending on the topic of the Delphi activity or the style of contributions, it may be desirable for a facilitator to screen responses, removing identity-revealing information or discarding contributions that do not address the problem. A moderator will also be able to detect when discussion has reached an impasse, and what an appropriate response might be. While a successful Delphi panel may be able to remain focused and develop appropriate solutions without intervention, having a human moderator able to step and a refocus the group will likely be a component of each e-Delphi exercise.

Leadership roles need not remain constant, however, and team members may rotate as moderators or may act as moderators of Delphi activities of their own creation. Because

e-Delphi activities can be created and executed quickly, any group member may be allowed to call for participants to his or her own Delphi question. In large e-Delphi activities, the panel may be divided into subgroups according to expertise or interest, with each subgroup's moderator responsible for developing that group's contributions to the larger exercise. The e-Delphi system should be developed such that response management tasks will be accomplished by the system, freeing human moderators to focus on tasks related to the domain problem, such as:

? "[Improving] the understanding of participants through analysis of subjective judgments to produce a clear presentation of the views and considerations
? [Detecting] hidden disagreements and judgmental biases that should be exposed for further clarification
? [Detecting] missing information or cases of ambiguity
? [Detecting] patterns of information and sub-group positions
? [Detecting] critical items that need to be focused upon"

(Turoff and Hiltz)

HERO's e-Delphi tool

The spatial dispersion of monitoring sites and researchers is a fundamental characteristic of the HERO network, making effective communication between sites critical to the project's success. Face-to-face group meetings, email, and e-notebook contributions are all vital means of communication; the e-Delphi effort cannot replace any of these, but it can offer team members a unique forum for defining priorities and framing a common understanding of the problems the project addresses.

Creating a web-based e-Delphi tool allows team members ready access to a highly flexible communications tool, using existing infrastructure to which there is worldwide access. Because no client other than a web browser is required, the e-Delphi system can undergo continuous – and often transparent – improvement. Centralized management of the system allows quick turnaround from initial idea to finished Delphi exercise, a familiar interface for each activity, and the ability for remote moderators to construct unique Delphi exercises that interact with the single core database. HERO can easily exploit the flexibility that Delphi offers by experimenting with different Delphi tools (e.g., ballots or Likert scales), different types of questions, and different panel constitutions.

Regardless of the outcomes of a Delphi exercise, the process itself is a useful method of knowledge elicitation and acquisition. In unstructured communication and in many face-to-face meetings, much of the content and context of discussion can be lost. By contrast, every contribution to an electronic Delphi exercise is logged; a rich knowledge base results from records of when, where, what, and how each participant contributed. Thus, the e-Delphi effort dovetails with HERO's e-notebook and XML tagging work, providing source material to each.

Implementation

This section provides a brief overview of the technical aspects of the e-Delphi system. The heart of the system is relational database that stores participant and contribution data. Each participant is assigned a 5-digit identification number (PIN) that is used to identify his or her contributions. This PIN also regulates access to the e-Delphi system, and each e-Delphi activity can be made available to all those with a valid PIN or to only a select group (for example, small e-Delphi activities for HERO members at a specific site). A random PIN, rather than a user-selected penname, is used as each participant's identifier so that the same anonym can be used when participating in other HERO collaborative activities that require anonymity. Each participant's contributions can be associated with the PIN as well as the date, time, and theme or thread to which the contribution belongs. Other participants can sort contributions by these attributes to view the set of responses in different ways.

The e-Delphi main web page (http://hero.geog.psu.edu/collaboratory/eDelphi) provides a schedule of HERO's Delphi activities. Green "Go" icons indicate those sessions that are currently open for participation. More detailed instructions on the use of the system are available at http://hero.geog.psu.edu/collaboratory/eDelphi/Delphi_desc.htm.

References

Adler M and Ziglio E 1996, *Gazing into the Oracle: The Delphi Method and its Application to Social Policy and Public Health*, Philadelphia: Taylor and Francis, 264 p.

Cornish E 1977, *The Study of the Future,* Washington, DC: World Future Society, 307 p.

Delbecq AL, VandeVen AH and Gustafson DH 1975, *Group Techniques for Program Planning: A Guide to Nominal Group and Delphi Processes*, New York: Scott-Foresman, 174 p.

Helmer O 1983, *Looking Forward: A Guide to Futures Research,* Beverly Hills, CA.: Sage, 376 p.

Khorramshahgol R, Azani H, and Gousty Y 1988, An integrated approach to project evaluation and selection, *IEEE Transactions on Engineering Management* 35(4), 265-270.

Linstone A and Turoff M (eds) 1975, *The Delphi Method: Techniques and Applications*, Reading, MA: Addison-Wesley, 620 p.

Murry J and Hammons JO, 1995, Delphi: A Versatile Methodology for Conducting Qualitative Research, *The Review of Higher Education* 18(4), 423-436.

Turoff M and Hiltz SR, Computer Based Delphi Processes, http://eies.njit.edu/~turoff/Papers/delphi3.html