Expert Consultation in the Preparation of a National Technology Programme

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This paper reviews theory pertinent to expert consultation and presents a case study conducted as a part of the preparation of a national technology programme in Finland. The paper develops a typology for the application of interviews, internet questionnaires,

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workshops, and the Delphi method, as well as reports observations from the case. These observations indicate that workshops can produce more profound insights than internet questionnaires and interviews, if the viewpoints of participating experts are contested against each other. We conclude that workshops seem to be well suited for consultations that are multidisciplinary and ambiguous in nature, such as preparatory investigations for a technology programme. However, we conjecture that several consultation methods used in complementary roles may produce even better results in such cases.

Keywords: Conflict, Consultation, Expert, Medical Biomaterials, Naturalistic Setting, Technology Programme, Workshop.

1 Introduction

Expert consultation has a long tradition. Whenever the knowledge of a decision maker has been lacking, the assistance of experts has been sought to supply relevant information or to make judgements for the decision maker. Expert consultation and decision making has been researched extensively by psychologists (see, e.g., Plous, 1993) and other researchers. Also related topics, such as knowledge elicitation techniques (see Hoffman and al., 1995), expert task characteristics (e.g. Stewart et al., 1997), communication media (e.g. Daft and Lengel, 1986), and group dynamics (e.g. Steiner, 1972), have received much attention. However, psychologists have conducted few experiments in naturalistic settings[1], where experts are consulted about ill-structured and unbounded problems (Saritas and Oner, 2003), but researchers and practitioners of technology assessment and foresight have done so in several occasions (see, e.g., Salo et al., 2003). Recently, psychologists have called for more rigorous analysis of the processes underlying expert consultation methods used in naturalistic settings, such as the Delphi method (Rowe and Wright, 1999). This paper attempts to follow that suggestion by reviewing literature relevant to expert consultation, developing a typology for the application of expert four consultation methods, reporting a case study conducted in a naturalistic setting, and analysing its results. In the case study, experts were consulted about commercialization challenges of biomaterial research in Finland as a part of the preparation of a national technology programme. This topic was multidisciplinary and ambiguous and involved several uncertainties and incomplete information. Therefore, consultation of several experts from different disciplines and decomposition of the topic were required. Three different consultation methods were applied in the case: interviews, internet questionnaires, and workshops.

In Section 2, this paper presents a review of relevant research on experts and expert groups. Section 3 analyzes the characteristics of four consultation methods (interviews, questionnaires, workshops, and the Delphi method) and develops a typology for their application. Section 4 presents the case study, and its results are reported in Section 5. The implications of the case are discussed in Section 6, and the paper ends in conclusions in Section 7.

2 Expert Research

In expert consultation, consulters are typically interested in the quality and quantity of expert judgements (cf. Barki and Pinsonneault, 2001). These typically depend on (1) how much the experts know about the topic, (2) how efficiently the consultation method is able to elicit information, (3) how the consultation method assists or impedes experts in making judgements, and (4) how well the consultation method is suited to the characteristics of the consultation topic (e.g. ambiguity and uncertainty).

2.1 Experts

Shanteau (1992) defines an expert as a person who has been recognized within their profession as having the necessary skills and abilities to perform at the highest level. Shanteau's (1992) theory proposes that the expert competence derives mainly from four characteristics: *domain knowledge*, *psychology traits*, *cognitive skills* and *decision making strategies*. In this paper, we are mainly interested in experts' knowledge about different domains. In most naturalistic settings, experts need to cope with uncertainties. Often uncertainties result from *inadequate understanding* (usually due to incomplete information or the abundance of conflicting meanings) (cf. Lipshitz and Strauss, 1997) rather than inherently random nature of processes. Uncertainty due to inadequate understanding can be coped with by getting additional information, for example, by asking people who know or reading appropriate books. When no additional information is available, it is possible to reduce uncertainty by extrapolating from available information (Lipshitz and Strauss, 1997).

For the purposes of this paper, the process of decision making is a particularly important sequence of expert tasks. In most decision process models, at least three phases are identified (Noorderhaven, 1995): (1) problem identification and structuring, (2) generation of alternative solutions, and (3) evaluation of alternative solutions. The decision is made when the best evaluated alternative is chosen.

2.2 Expert Groups

Expert groups are often used in consultation processes, because groups have more informational resources at their disposal than individuals do (Franz and Larson, 2002). In groups, individuals need not meet all knowledge requirements of their task, because other group members may complement them. However, some overlapping knowledge (or functional redundancy) is useful, because it acts as a common ground among group members and facilitates learning (Kasvi et al., 2000).

A group needs to co-ordinate how it utilizes its members in task completion. The group has to decide how individuals contribute to the task completion and how their contributions are taken into account in the group outcome. Also, the group needs a way to resolve internal conflicts, for example when two or more experts present conflicting viewpoints. Amason and Schweiger (1994) distinguish cognitive conflict from affective conflict. *Cognitive conflict* refers to disagreement or controversy over the best way to achieve a group goal. Cognitive conflict contributes to decision quality because the synthesis that emerges from the contesting of the diverse perspectives is generally superior to the individual perspectives themselves (Amason, 1996). *Affective conflict* emerges when cognitive disagreement is perceived as personal criticism or offensive behaviour. Affective conflict generally results in negative perceptions of other group members and, subsequently, negative interpersonal behaviours (Amason, 1996).

Co-ordination of group work is not straightforward, and researchers have identified several cases when groups have performed less efficiently than individuals (see, e.g., Barki and Pinsonneault, 2001). One important reason for dysfunction is that norms of group interaction may cause group members to refrain from making their own judgements. For example, the results of Asch (1961) indicate that a group may create a social pressure to conform to the majority’s opinion, even if it were obviously false. Janis (1982) perceived that group members may neglect task-relevant information and suppress their own judgement in order to please the group leader and reach consensus. Furthermore, a study by Milgram (1974) provided evidence that people tend to obey authorities and trust their judgements. These group phenomena may follow from *evaluation apprehension* (Henchy and Glass, 1968), that is, people are unwilling to express their own views in fear of others’ negative response.

Also, working in a group per se poses restraints for group members. Especially face-to-face groups suffer from *production blocking*, which refers to group members' inability to contribute when others are speaking (Mennecke and Valacich, 1998). Therefore, it is often efficient to divide a large group into sub-groups which work concurrently on different parts of the task. These parts may also be easier to complete, because they pose fewer informational and cognitive demands than the whole task.

2.3 Differences between Laboratory and Naturalistic Settings

Experts have been traditionally researched by psychologists in controlled laboratory settings, where subjects have been undergraduate students (cf. Shanteau, 1992). These settings differ in several ways from those that are encountered in naturalistic expert consultations. Henry (2000), Kramer et al. (2001) and Shanteau (1992) describe differences between laboratory and naturalistic settings in the context of social dilemmas, brainstorming, and expert work, respectively. Table 1 presents a summary of the differences found by these authors, complemented with our comments in italic.

Overall, laboratory research has been usually carried out in conditions that have been disconnected from the reality and have had few incentives. The group has been composed of naïve or novice subjects (typically undergraduate students), who have been assigned to work on a simple task, using methods and communication media determined by the researchers. The subjects have had little control over the situation. The experiment has been temporary and actions taken in it have had little influence on other tasks. On the other hand, variables of interest are easy to isolate in laboratory conditions, and the test can be usually designed so that the sample size is large enough for statistical testing.

In a naturalistic setting, participants may have economic incentives and other motivations to participate. In many cases, leading experts, professors and CEOs have a great deal of control over how the process unfolds, what communication media they use, and how much time they devote to the process. The process is connected to past and future events, and it usually takes much longer time than in laboratory settings.

Table 1. Differences of laboratory settings and naturalistic settings. Our comments are in italic.

Attribute	Laboratory Setting	Naturalistic Setting
Incentives (Henry, 2000)	Economic incentives are often very weak. *Participants do not have their own agenda.*	Economic incentives. *Achievement, power and affiliation motivations (cf. McClelland, 1974).* *Participants have their own agenda.*
Participants' communication (Henry, 2000)	Participants' communication is controlled. They are told which topics to discuss, how long to discuss, and what communication medium to use.	Discuss any topic, use any available communication medium. *The agenda and norms influence participants' behaviour.*
Unfolding time (Henry, 2000)	One-shot experiment, typically within a short, defined period of time	Long unfolding times, e.g. months or years
Task interdependence (Kramer et al., 2001)	None, disconnected from other tasks	Past and future, connected to other tasks
Participant relationship (Kramer et al., 2001)	None, a temporary ad hoc group	Past and future relationships among participants
Task characteristics (Shanteau, 1992)	Simple, well-defined	Complex, ambiguous
Group / Expertise (Shanteau, 1992)	Usually undergraduate students / Naïve or novice	Experts / High expertise

3 Consultation Methods

In this context, consultation can be defined as "an inquiry of information from one or more individuals." If the individuals are experts in the domain of the inquired information, we speak of expert consultation. Experts can be consulted in several different ways, each of which has advantages and disadvantages depending on the situation. The most typical consultation methods are questionnaires and face-to-face interviews. Consultation methods are similar to knowledge elicitation (KE) techniques used by experimental and applied psychologists and developers of expert systems (analysis of familiar tasks, interview methods, and contrived tasks; see Hoffman et al., 1995) in that they both attempt to tap into experts' knowledge.

Three consultation methods used in the case study – questionnaires, face-to-face interviews, and workshops – and the Delphi method are compared with each other in this section, and a typology for their application is developed.

3.1 Definitions

The scrutinized consultation methods are defined as follows:

A questionnaire is a set of questions for obtaining statistically useful or personal information from individuals (Merriam-Webster Online Dictionary). An internet questionnaire is a special form of a questionnaire that can be filled in and returned in the internet using a web browser.

An interview is a meeting at which information is obtained (as by a reporter, television commentator, or pollster) from a person (Merriam-Webster Online Dictionary).

A workshop is a meeting emphasizing interaction and exchange of information among a usually small number of participants (cf. AHD4).

The Delphi method uses a series of questionnaires, known as "rounds." Input from each round is gathered, analyzed, and fed back to participants in the next. Typical feedback includes the median and the interquartile range of group response and the rationale for agreement or disagreement within the group input. The process continues until response stabilizes, which means usually no more than four rounds. (Porter et al., 1991; Linstone and Turoff, 1975)

3.2 Characteristics

The characteristics of questionnaires, interviews, workshops, and the Delphi method in light of the communication media theory (Daft and Lengel, 1986) and expert collaboration possibilities are summarized in Table 2.

Table 2. Characteristics of the consultation methods.

Property	**Consultation method**		
	Immediacy of feedback	**Informational cues**	**Expert collaboration**
Questionnaire	No feedback cycle	Text, anonymous	No
Interview	Immediate	Voice + Visual cues	No
Workshop	Immediate	Voice + Visual cues	Face-to-face
Delphi	Days or weeks (after each round)	Text, anonymous	Statistical group response

Immediacy of feedback refers to how fast the consulter can react to the information provided by the expert. According to Daft and Lengel (1984), feedback cycles enhance media richness, because communication can be directed to most relevant issues at each feedback point. Usual questionnaires do not have feedback cycles, and therefore the direction of the consultation is limited to instructions. An interviewer, however, can direct the consultation based on what the interviewee replies, given that the interview is semi-structured or unstructured. The same is true with workshops, in which the facilitator and participants can immediately react to presented information. Feedback cycles are often used by experienced chairmen in workshops and electronic meetings to direct the process at important issues that have not been on the agenda but have emerged during discussions (Niederman and Volkema, 1999).

Informational cues transmit information in communication. Questionnaires use text, whereas interviews and workshops are face-to-face events, in which communication occurs through voice and visual cues. According to Daft and Lengel's (1986) media richness theory, experts can communicate task-relevant information more efficiently in interviews and workshops than through writing questionnaire replies. On the other hand, text-based replies can be anonymous, wherefore experts may be more eager to express controversial viewpoints.

Expert collaboration refers to the possibility for consulted experts to interact and exchange information. Collaborating experts can support each other in terms of what is known, and therefore individual experts may be able to make more informed judgements than if they were consulted in isolation of each other. The benefits of expert collaboration are most salient in multidisciplinary consultations, in which individual experts may be unaware of some important perspectives and facts pertaining to the topic. Collaboration has its costs, though. Collaborating experts may suffer from evaluation apprehension and other dysfunctional group effects, which may affect negatively to their judgements.

3.3 Application Typology

Here, a typology is developed to illustrate different fields of application of interviews, internet questionnaires, workshops, and the Delphi method. Our typology consists of three dimensions: *the number of related disciplines*, *the ambiguity of the topic*, and *the number of consulted experts* (see Table 3).

Table 3. The application typology of four expert consultation methods. Divisions among categories are rough estimates.

Related Disciplines	Ambiguity of Topic	Number of Experts	Consultation Method
One	Unambiguous	Less than 20	Interview
One	Unambiguous	20–200	Questionnaire
One	Unambiguous	Over 200	Questionnaire
One	Ambiguous	Less than 20	Interview
One	Ambiguous	20–200	Any, no clear preference
One	Ambiguous	Over 200	Delphi
Multiple	Unambiguous	Less than 20	Workshop
Multiple	Unambiguous	20–200	Workshop
Multiple	Unambiguous	Over 200	Delphi
Multiple	Ambiguous	Less than 20	Workshop
Multiple	Ambiguous	20–200	Workshop
Multiple	Ambiguous	Over 200	Delphi

The number of disciplines is an important factor, because the domain knowledge of many experts extends to only one discipline. When a consultation concerns a multidisciplinary topic, experts may need to discuss with specialists of disciplines other than their own before they are able to make well-informed judgements. Therefore, it is proposed that methods, such as workshops and Delphi, which include information exchange between participating experts, should be used when consulting about multidisciplinary topics.

The second dimension is important, because when the consultation topic is ambiguous (i.e. it has multiple conflicting meanings; cf. Weick, 1995), experts may understand questions differently than intended and consulters may also misinterpret experts' replies. Therefore, in such cases, it is best to apply a method, in which iterations of replies are possible or a communication channel between consulters and experts exists. Hence, it is suggested that consultations methods, such as interviews, workshops, and Delphi, should be applied with ambiguous topics.

The number of consulted experts is a main concern with respect to the effort required for consultation. For large expert samples (ca. more than 200), it is suggested to use methods, such as internet questionnaires and Delphi, which are able to cover the whole sample with relatively little effort per expert. For a small number of experts (ca. less than 20), it is easiest to interview the experts or organize a single workshop. For medium-sized expert groups (ca. 20–200), workshops, questionnaires, and Delphi exercises, come into question.

In summary, interviews are applicable, when the number of experts is small and the topic is not multidisciplinary. Questionnaires suit best for simple consultations with a large sample of experts. Workshops are most useful for consulting about multidisciplinary and ambiguous topics, except if the expert sample is very large. Finally, the Delphi method fits for consultations with a large expert sample, when feedback cycles are required due to multidisciplinary nature of the topic or ambiguities involved.

4 Case

4.1 Background

Technology programmes are one of the most important tools for the implementation of the strategy of Tekes, the National Technology Agency[2]. They serve as frameworks for intensive research in nationally important areas and aim at significant economic and social effects. In these programmes university researchers, research institutes and private enterprises are committed to work together to achieve common goals. Technology programmes provide a framework for national and international networking.

In early 2001, first ideas of organizing a national programme on medical biomaterials surfaced among Tekes experts. Medical biomaterials are regarded as a new growing industrial sector in Finland. The research in the field is concentrated on developing materials that can be used in a human body without adverse effects, i.e. biocompatible materials, or briefly biomaterials. One of the greatest challenges in medical biomaterials research is the large number of related disciplines: medicine, biochemistry, molecular biology, pharmaceutics, chemistry, physics, and engineering sciences. Researchers have typically studied only one of the disciplines, being physicians developing healthcare applications, biochemists researching the effects of materials on the human body, and information scientists manufacturing biocompatible sensors, among others. The field is new enough that practices for commercializing research results have not been fully developed, and, hence, commercial activities are relatively scarce in the field. Tekes experts anticipated that a properly designed technology programme could promote the creation of successful commercialization practices and, subsequently, new businesses. Therefore, investigations for the viability of such a programme were started. As a standard measure, they announced a preliminary call for proposals, in which they invited researchers and companies to send suggestions for research and development projects, which they were interested in carrying out in the programme. Received suggestions were used to estimate if there was sufficient interest for the programme. The call received 51 replies, which was regarded as a sufficient number.

Furthermore, the viewpoints of industry and researchers about the technology programme were investigated through an expert consultation process, which included interviews, internet questionnaires, and workshops. Multiple methods were used for a number of reasons. First, interviews were a standard and obligatory part of the programme preparation process. Second, it was considered that a consultation through workshops could be efficient in programme preparation, due to multidisciplinary and ambiguous nature of medical biomaterial research and innovation processes. Workshops had not been applied before in programme preparation, but promising experiences had been gained in programme evaluations (see, e.g., Salo et al., 2003). Third, it was considered that workshops would be most fruitful, if they were prepared by a pilot study (cf. van Zolingen and Klaassen, 2003), which would make it possible to utilize input from the experts in the design of the workshop agenda and also make the experts to take time to elaborate their viewpoints. For this purpose, experts were asked to fill in internet questionnaires[3]. A Delphi study was not applied in this case, because the number of consulted experts was not particularly large (no more than 60).

4.2 Expert Consultation

4.2.1 Interviews

Interviews with key players of the industry and research units were conducted by a *programme agent*, an external consultant hired by Tekes to assist in the preparation of the programme. He discussed with 20 biomaterial experts in 2–3-hour interviews. The interviews included questions about the vision for biomaterial companies in the year 2010, the most essential difficulties for their growth, and support measures for commercialization that would be useful to incorporate into the programme. The experts were also asked about what they thought about basic research in the field and what branches of research the technology programme should cover in their view. The programme agent synthesized a separate report and two workshop presentations from the results of the interviews.

4.2.2 Internet Questionnaires and Workshops

In a joint effort of Tekes and Helsinki University of Technology, experts were consulted through four workshops and four internet questionnaires. The process was organized by two Tekes experts, the programme agent, and a researcher from Helsinki University of Technology. To this consultation, Tekes experts chose 20 commercialization specialists and 40 experts, who had replied to the preliminary call for proposals. Invitations to the process were sent through email. 35 technology experts and 11 commercialization experts responded positively to the invitation. 70% of them came from universities or research organizations, 24% from companies, and 6% from other organizations. Participation to the consultation was voluntary, and no monetary incentive was offered. Part of the participants had met each other previously, but they were in minority.

The experts were consulted about commercialization challenges of biomaterials field in Finland. The consultation was divided into four questions:

(1) What promising future biomaterials are developed now in Finland (as to be suitable for commercialization),

(2) what are now the commercialization challenges in biomaterial research in Finland,

(3) how the challenges should be addressed, and

(4) what support measures should be incorporated into the biomaterial programme to facilitate the commercialization of biomaterial research?

The questions formed a sequence of a decision making process. The first and second questions belonged to the problem identification and structuring step, in which experts mainly recalled relevant information they possessed. The third question was essentially a solution generation task, and the fourth one consisted of an evaluation of generated alternatives.

The informational demands of the consultation topics were considered to be rather high (including biomaterial research, relevant commercialization processes, legislation issues, and internationalization strategies), and therefore the consultation was divided into four technological themes[4]:

(1) raw materials (of biomaterials)

(2) implants

(3) tissue engineering

(4) drug delivery.

Invited experts were distributed among these themes, either according to their fields of specialty or Tekes expert's views of where the experts could contribute best (e.g. by providing alternate viewpoints). It was also take care of that researchers and industrial representatives were represented in similar proportions in each theme.

Each theme had one internet questionnaire, and thus there were a total of four internet questionnaires. The internet questionnaires were used to elicit the experts' personal viewpoints about five content questions:

(1) What research milestones are anticipated to be achieved during the next 10 years in Finland,

(2) what research and development activities should be strengthened in Finland,

(3) what changes are hoped for in the innovation environment (e.g. education),

(4) what support measures should be incorporated into the planned technology programme, and

(5) what thoughts did future scenarios[5] inspire?

The experts replied to these questions anonymously. The questionnaires also served orientation and information sharing functions. When experts familiarized themselves with the questions of the internet questionnaire, they also prepared themselves for the workshops. The replies were distributed to workshop participants at the beginning of the workshops, which provided experts with a look at each others' viewpoints. In total, 31 experts filled in one of the questionnaires.

One workshop was organized for each theme, and hence there were a total of four workshops. Workshops were based on the rationale that several experts from different backgrounds possess more informational resources than individuals do, wherefore they are together more capable in dealing with multidisciplinary tasks. Also, participation in the programme preparation was considered to increase experts' commitment to the goals of the programme (cf. Vroom and Yetton, 1973). Furthermore, workshops acted as opportunities for networking for researchers, company representatives, and commercialization specialists, which is deemed crucial for creation of successful innovations in multidisciplinary environments (Powell et al., 1996).

The main workshop agenda was divided into two parts. The first main topic was the future prospects of medical biomaterials, which included also discussion of relevant commercialization challenges. It started with the programme agent's presentation, which he had prepared on the basis of international reports and his interviews. At this point, the participants were also provided with the replies to the internet questionnaires. The purpose of this part of the workshops was to act as a problem identification and structuring exercise. The second main topic was the discussion of support measures. This phase was set up by the programme agent's presentation of six suggestions for support measures, such as a quality system and legislative aid. Experts evaluated the support measure suggestions with regard to how they needed them in their research. The evaluations were qualitative and judgmental in nature, mostly justifications why different support measures would or would not be needed by particular experts. The purpose of this point was the evaluation of different alternatives, in order to highlight the need for them and their possible impacts. The highlights of these discussions were captured into an electronic mind map[6], which was projected on the wall throughout the whole process. The workshops lasted for about four hours, and after they were formally over, a feedback questionnaire was given to the participants.

Each workshop was chaired by a member of the workshop organization team, who was familiar with medical biomaterials: one of the Tekes experts (two first workshops) or the programme agent (two last workshops). Although the chairmen were owners of the programme preparation task, they were rather neutral with regard to the interests of different key players, such as universities, research institutes and companies. The university researcher was responsible for the technology and practical arrangements at the workshops. He also recorded discussions on mind maps.

5 Case Analysis

The analysis of the case was based on three sets of data: the replies to the internet questionnaires, the comments recorded on the mind maps at the workshops, and the replies to the feedback questionnaire. First, a comparative analysis was carried out on the internet questionnaire replies and the mind maps. It was expected that differences in the data sets would reveal important characteristics of internet questionnaires and workshops, as they had been used to consult almost the same expert population. Second, the results of the feedback questionnaires were analyzed. They were expected to shed light upon participants' perceptions of the usefulness of workshop consultation as a part of programme preparation.

5.1 Content Analysis

The replies to internet questionnaires and comments recorded on mind maps were analysed as to how they contributed to the identification and solving commercialization challenges of medical biomaterials. First, we screened the replies and comments for relevant ones, which resulted in 107 questionnaire comments (there could be more than one comment per reply) and 195 mind map comments. These comments were grouped until major categories were identified, and the distribution of comments among these categories was counted. A major category was considered to be one that included at least 10 % of all comments. Categories were combined with similar ones, to prevent inappropriate judgements of unimportance based on the granularity of categorization. In both the questionnaires and the workshops, three major categories were common:

(1) research collaboration,

(2) commercialization support, and

(3) legislation.

Additionally, the workshops yielded two major categories, which did not appear in the internet questionnaire:

(4) quality system and

(5) technology development strategies.

The internet questionnaires included a total of 83 comments (78 % out of 107), which belonged to the major categories (1) to (3) (see Table 4). The mind maps contained a total of 171 comments (88 % out of 195), which belonged to the major categories (1) to (5) (see Table 5).

Table 4. Analysis of the internet questionnaires. Total number of comments N = 83.

Internet questionnaire	Raw materials	Implants	Tissue Eng.	Drug release	Total
Research collaboration	10 %	11 %	6 %	16 %	**42 %**
Commercialization support	19 %	16 %	5 %	5 %	**45 %**
Legislation	4 %	6 %	1 %	2 %	**13 %**
Total	**33 %**	**33 %**	**12 %**	**23 %**	**100 %**

Table 5. Analysis of the mind maps. Total number of comments N = 171.

Mind Maps	Raw materials	Implants	Tissue eng.	Drug release	Total
Research collaboration	0 %	6 %	2 %	6 %	**14 %**
Commercialization support	5 %	5 %	9 %	8 %	**28 %**
Legislation	5 %	6 %	9 %	12 %	**32 %**
Quality system	0 %	3 %	7 %	2 %	**12 %**
Technology development strategies	5 %	5 %	2 %	4 %	**15 %**
Total	**15 %**	**25 %**	**29 %**	**30 %**	**100 %**

(Percentages may not sum up exactly due to rounding errors. All numbers have been calculated by using exact values.)

Table 6. Percents of comments devoted to legislation and quality system within each questionnaire and workshop.

Legislation & quality system	Raw materials	Implants	Tissue eng.	Drug release	Total
Questionnaire replies	11 %	19 %	10 %	11 %	**13 %**
Workshop discussions	35 %	35 %	56 %	44 %	**44 %**

Scrutinizing these tables, it can be observed that the tissue engineering questionnaire generated fewer comments than the other three, which is partly due to the lower number of respondents to that questionnaire (6 respondents, others had 8 or 9).

Second, the number of comments in the mind maps increases from the first to last workshop. It may reflect the quickness of the technical facilitator to record comments in addition to the amount of discussion.

Third, legislation received remarkably more attention in the workshops than in the questionnaire (32 % vs. 13 %), and the percentage of comments pertaining to quality system and legislation increases noticeably in two last workshops (see Table 6). This increase can be explained by the fact that the quality system and legislation were deemed very important by the programme agent, and they had a central role in his presentations. The programme agent also facilitated two last workshops. This observation can be regarded as an implication of the effect of the agenda, facilitation, and preparatory presentations on the topics covered in discussions.

Fourth, the number of comments on research collaboration issues was considerably lower in the workshops than in the internet questionnaire (14 % vs. 42 %). We conjecture that research collaboration issues had been discussed extensively even before workshops (they had been very salient in Tekes programmes for years), and they were left into background when new important topics emerged at the workshops.

Fifth, the workshops produced also discussion that was not advocated by the chairmen or reported in the internet questionnaire by individual experts. Roughly 15 % of comments dealt with how to allocate efforts among the development of new and existing technologies. (This observation is discussed further in Section 6.1.)

5.2 Feedback Analysis

Feedback was gathered through questionnaires at the end of the workshops. They included five statements, to which the participants responded on a 7-point scale ranging from 1 = strongly disagree to 7 = strongly agree. Additionally, the questionnaires had free space for comments. Table 7 shows the average of the replies to the five statements. We received replies from the participants who stayed till the end of the workshops and did not leave in haste (33 out of 46 participants).

Table 7. Results of the feedback questionnaire (scale 1–7).

Question	**Individual Workshops**				**Total**	
	Raw mat.	**Impl.**	**Tissue eng.**	**Drug del.**	**Avg.**	**No. of replies**
1. Relevant key players of the field were well presented in the workshop.	6.3	5.3	5.1	5.9 2)	**5.7**	32
2. The workshop concentrated on relevant questions.	6.5	5.5 1)	5.5	6.2 2)	**6.0**	27
3. The replies to the internet questionnaire were a good starting point for discussion.	5.7	5.1	4.7	5.8	**5.3**	33
4. Mind Map application was helpful in the workshop.	6.2	5.4	4.6	5.6 2)	**5.4**	32
5. Similar workshops are worth organizing in the future.	6.7	6.4	5.9	6.8	**6.5**	33
Number of returned feedback forms	*6*	*7*	*8*	*12*	***33***	-

1) 2 participants out of 7 replied to this question.
2) 11 participants out of 12 replied to this question.

The results were used to measure participant satisfaction. Strong support was given to the workshops in general (question 5; total average 6.5) and the topics on the agenda (question 2; total average 6.0). Interestingly, the workshops in general received higher scores than any detailed topics, such as the agenda or the application of a mind map. Therefore, it appears that an important factor, which would explain the high score, has been missed by the questions. (This observation is discussed further in Section 6.2.)

Another observation was the variability of satisfaction among the workshops. The tissue engineering workshop received a bit lower scores to every question than the other three. It had only one company representative, and therefore industry-research interaction was much weaker than in other workshops, which had three or four representatives from industry. Furthermore, this workshop also had the lowest number of participants (9, other workshops had 12 or 13) and the lowest number of technology experts (6, other workshops had 8 to 11). However, other factors, such as facilitation, may have also reduced the scores.

6 Discussion

6.1 Emergence of Technology Development Strategies

Interestingly, in every workshop the experts raised the question how to allocate research and development efforts between new and existing technologies, even though it was not on the agenda. This question was an important one and previously not discussed during the preparation of the programme. In our view, the question arose from cognitive conflict between researchers and company representatives. Researchers are generally interested in developing new technologies, because the publication of novel results yields more attention in the scientific community. However, companies are interested in developing existing technologies into products, which can be sold for profit. This conflict of interests evoked discussion, in which experts had to justify their positions. In doing so, they shared unique information that was not acquired via other consultation methods.

6.2 High Workshop Satisfaction

Interestingly enough, the workshops received a very high overall satisfaction score (6.5 out of 7 on the average), which had no obvious explanation. It can be concluded that the participants had found the workshops useful and pleasant, although why they did so was not evident from the feedback. We suspect that, as argued above, the process of cognitive conflict resulted in insightful discoveries, which subsequently increased participant satisfaction. This leads to an intriguing realization: cognitive conflict did not cause affective conflict, which would have reduced satisfaction (cf. Devine, 1999).

We find two reasons for the absence of affective conflict. First, the workshop participants were not explicitly defending any positions, wherefore they had few political pressures. The project suggestions of technology experts were decidedly excluded from the workshops discussions to avoid defensive behaviour. Second, the workshops were chaired by persons, who had not committed themselves to particular technologies or viewpoints. For example, the chairmen did not have a preference between basic research and product development. Therefore, we argue that experts did not feel a need to suppress their own judgement in order to please the chairmen (cf. Janis, 1982; Milgram, 1974). Still, they may have felt evaluation apprehension and pressures to conform to the majority's opinion, but given the diverse backgrounds of the participants and the group's early stage of development, we think that their effects were rather small. We argue that, since the experts did not suppress their own judgements, they shared plenty of unique information, which was also reflected in high participant satisfaction.

Our conclusion from this discussion is that workshop participants should feel safe to present differing viewpoints. Therefore, workshops should not have superiors and subordinates, participants from closely collaborating research units or companies, and people with negative past experiences with each other. Furthermore, sensitive or personal issues, which experts are likely to be defensive about, should be avoided. Neutral facilitation and norms that promote open discussion (e.g. the facilitator may explicitly tell that differing viewpoints are desired) are also useful for reducing experts' concerns about others' possible negative responses.

6.3 Impacts of the Expert Consultation Process

The results of the consultations were utilized in the design of the programme proposal for the board of directors of Tekes. In January 2003, the proposal was approved and the procedures for starting up the programme were initiated. Since the internet questionnaires and workshops were new methods in this context, it is compelling to try to estimate their impacts on the approval of the proposal. However, we do not know what factors influenced the final decision of the board of directors, but, on the other hand, it is certain that internet questionnaires and workshops provided Tekes experts with a considerable amount of additional information, which helped in the design of the proposal. In the view of Tekes experts, the starting point for the programme was considerably better informed than what it would have been without the process. Therefore, we conclude that the process succeeded in increasing the understanding of Tekes experts of the state of Finnish biomaterials and providing them with useful evaluations of the alternatives for programme support measures. Workshops also provided the participating experts with an opportunity to network, which resulted in several new contacts among them.

6.4 Complementary Roles of Consultation Methods

Workshops, internet questionnaires, and interviews were not applied separately of each other in the case study, but they had complementary roles. The interviews elicited personal viewpoints of experts, which were used as a basis for workshop presentations. The internet questionnaires prepared the experts for the workshops in addition of eliciting their viewpoints anonymously. It may be that the application of several complementary consultation methods was one reason for the success of the process. The typology of the consultation methods described in Section 3, however, does not take into account how different methods can complement each other. It may be possible to build upon the strengths of several consultation methods by using outputs of one method as inputs to another one. However, further research is needed to examine such possibilities.

7 Summary and Conclusions

In this paper, we reviewed literature relevant to expert consultation. Furthermore, we developed a typology for the application of four consultation methods: internet questionnaires, interviews, workshops, and the Delphi method. The typology suggests that workshops are best suited for consultations that pertain to multidisciplinary and ambiguous issues. Interviews are most useful when the number of consulted experts is small. Questionnaires are best suited to consultation when the number of consulted experts is large, ambiguities are few, and only one discipline is concerned. Finally, the Delphi method is suggested to be used when the number of experts is large and the topic is ambiguous, uncertain, or multidisciplinary.

We also presented a case study, in which leading Finnish experts of medical biomaterials and commercialization were consulted via interviews, internet questionnaires, and workshops. The case yielded several notable observations, specifically the emergence of a new important topic in workshop discussions and high participant satisfaction. We concluded that cognitive conflict between researchers and industry representatives was most likely the reason for the identification of the new topic, and the absence of affective conflict contributed crucially to the high participant satisfaction. In our view, cognitive conflict seems to be a major antecedent of high quality viewpoints at workshops, but this hypothesis needs to be validated in more controlled conditions.

Overall, it seems that workshops are well suited for programme preparation, in which experts face uncertainties, ambiguities, and the multidisciplinary nature of innovation processes. However, it may be possible to use several consultation methods to complement each other, wherefore they may prove together more efficient than any method alone, but further research is needed to examine these avenues of expert consultation.

Notes

[1] The term "naturalistic setting" is adopted from Lipshitz and Strauss (1997). It refers to a normal setting, which does not incorporate the controls and constraints of a laboratory setting.

[2] Tekes is the main public funding agency for applied technological and industrial research and development in Finland. The role of Tekes is to enhance and secure the competitiveness of established industrial sectors and to promote and oversee the growth of new sectors. See http://www.tekes.fi/.

[3] The internet questionnaires were developed by using Opinions-Online® system. See http://www.opinions.hut.fi/.

[4] The themes were selected by Tekes experts on the basis of the project suggestions sent to the preliminary call for proposals.

[5] Three future scenarios were distributed to experts with the invitation e-mail.

[6] Mind Manager®. See http://www.mindjet.com/ for details.

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